باسمه تعالی

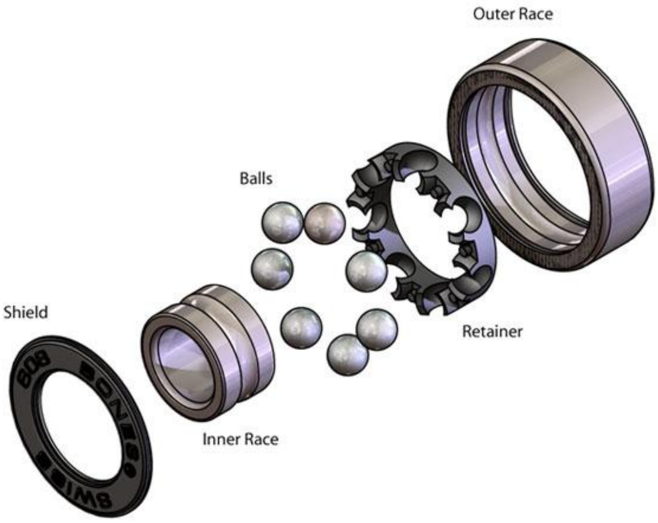
گزیده جداول و نمودارهای طراحی اجزاء ۲

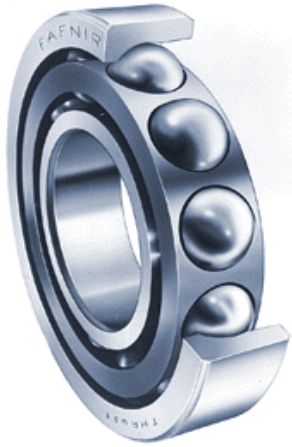
دکتر علیرضا دانش‌مهر

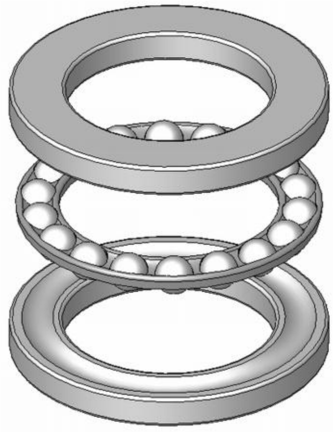
ویرایش اول

بهار ۱۳۹۴

۱. یاتاقان‌های غلتشی







Cages

Depending on the bearing series, design and size, SKF single row deep groove ball bearings are fitted as standard with one of the following cages (→ **fig. 9**)

- a pressed ribbon-type steel cage, ball centred, no designation suffix (**a**)
- a pressed ribbon-type brass cage, ball centred, designation suffix Y
- a riveted pressed steel cage, ball centred, no designation suffix (**b**)
- a riveted pressed brass cage, ball centred, designation suffix Y
- a machined brass cage, ball centred, designation suffix M (**c**)
- a machined brass cage, outer ring centred, designation suffix MA
- an injection moulded snap-type cage of glass fibre reinforced polyamide 6,6, ball centred, designation suffix TN9 (**d**).

Bearings having a pressed steel cage in standard execution may also be available with a machined brass or injection moulded snap-type cage of polyamide 6,6. For higher operating temperatures, cages of polyamide 4,6 or glass fibre reinforced polyetheretherketone (PEEK), designation suffix TNH, may be advantageous. Please check availability prior to ordering.

Note

Deep groove ball bearings with polyamide 6,6 cages can be operated at temperatures up to +120 °C. The lubricants generally used for rolling bearings do not have a detrimental effect on cage properties, with the exception of a few synthetic oils and greases with a synthetic oil base and lubricants containing a high proportion of EP additives when used at high temperatures.

For bearing arrangements, which are to be operated at continuously high temperatures or under arduous conditions, SKF recommends using bearings with a pressed steel or a machined brass cage.

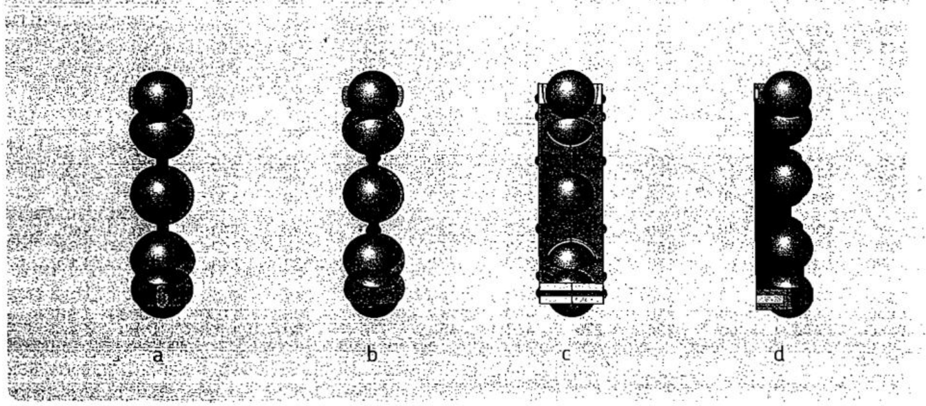
For detailed information about the temperature resistance and the applicability of cages, please refer to the section "Cage materials", starting on **page 140**.

Minimum load

In order to provide satisfactory operation, deep groove ball bearings, like all ball and roller bearings, must always be subjected to a given minimum load, particularly if they are to operate at high speeds or are subjected to high accelerations or rapid changes in the direction of load. Under such conditions, the inertia forces of the balls and cage, and the friction in the lubricant, can have a detrimental effect on the rolling conditions in the bearing arrangement and may cause damaging sliding movements to occur between the balls and raceways.

The requisite minimum radial load to be applied to deep groove ball bearings can be estimated using

Fig. 9



$C = P(L)^{1/n}$

$$F_{rm} = k_r \left(\frac{\nu n}{1\,000}\right)^{2/3} \left(\frac{d_m}{100}\right)^2$$

where

F_{rm} = minimum radial load, kN

k_r = minimum load factor (→ product tables)

ν = oil viscosity at operating temperature, mm^2/s

n = rotational speed, r/min

d_m = bearing mean diameter = 0,5 (d + D), mm

When starting up at low temperatures or when the lubricant is highly viscous, even greater minimum loads may be required. The weight of the components supported by the bearing, together with external forces, generally exceeds the requisite minimum load. If this is not the case, the deep groove ball bearing must be subjected to an additional radial load. For applications where deep groove ball bearings are used, an axial preload can be applied by adjusting the inner and outer rings against each other, or by using springs.

Axial load carrying capacity

If deep groove ball bearings are subjected to purely axial load, this axial load should generally not exceed the value of 0,5 C_0. Small bearings (bore diameter up to approx. 12 mm) and light series bearings (Diameter Series 8, 9, 0, and 1) should not be subjected to an axial load greater than 0,25 C_0. Excessive axial loads can lead to a considerable reduction in bearing service life.

Equivalent dynamic bearing load

$$P = F_r \quad \text{when } F_a/F_r \le e$$
$$P = X F_r + Y F_a \quad \text{when } F_a/F_r > e$$

The factors e and Y depend on the relationship $f_0 F_a/C_0$, where f_0 is a calculation factor (→ product tables), F_a the axial component of the load and C_0 the basic static load rating.

In addition, the factors are influenced by the magnitude of the radial internal clearance; increased clearance enables heavier axial loads to be supported. For bearings mounted with the usual fits as listed in the **tables 2**, **4** and **5** on **pages 169** to **171**, the values for e, X and Y are listed in **table 5** below. If a clearance greater than Normal is chosen because a reduction in clearance is expected in operation, the values provided under "Normal clearance" should be used.

Equivalent static bearing load

$$P_0 = 0{,}6\, F_r + 0{,}5\, F_a$$

If $P_0 < F_r$, $P_0 = F_r$ should be used.

$n = \frac{C_0}{P_0}$

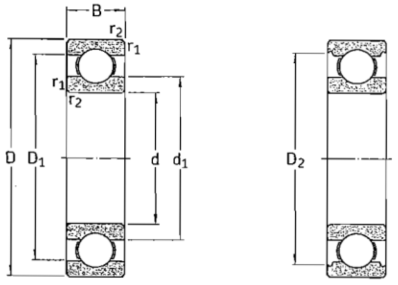
Table 5

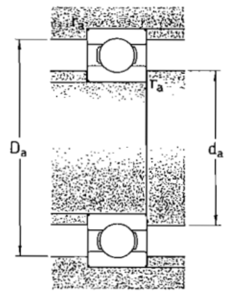
Calculation factors for single row deep groove ball bearings

$f_0 F_a/C_0$	Normal clearance e	Normal clearance X	Normal clearance Y	C3 clearance e	C3 clearance X	C3 clearance Y	C4 clearance e	C4 clearance X	C4 clearance Y
0,172	0,19	0,56	2,30	0,29	0,46	1,88	0,38	0,44	1,47
0,345	0,22	0,56	1,99	0,32	0,46	1,71	0,40	0,44	1,40
0,689	0,26	0,56	1,71	0,36	0,46	1,52	0,43	0,44	1,30
1,03	0,28	0,56	1,55	0,38	0,46	1,41	0,46	0,44	1,23
1,38	0,30	0,56	1,45	0,40	0,46	1,34	0,47	0,44	1,19
2,07	0,34	0,56	1,31	0,44	0,46	1,23	0,50	0,44	1,12
3,45	0,38	0,56	1,15	0,49	0,46	1,10	0,55	0,44	1,02
5,17	0,42	0,56	1,04	0,54	0,46	1,01	0,56	0,44	1,00
6,89	0,44	0,56	1,00	0,54	0,46	1,00	0,56	0,44	1,00

Intermediate values are obtained by linear interpolation

Single row deep groove ball bearings
d **3 – 10** mm



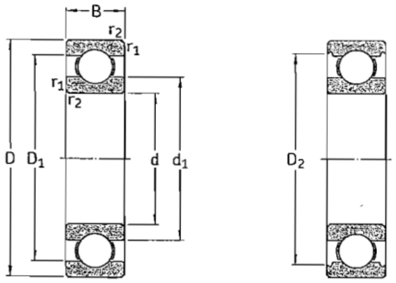


Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designation
d	D	B	C	C_0	P_u				
mm			kN		kN	r/min		kg	–
3	10	4	0,54	0,18	0,007	130 000	80 000	0,0015	**623**
4	9	2,5	0,54	0,18	0,007	140 000	85 000	0,0007	**618/4**
	11	4	0,715	0,232	0,010	130 000	80 000	0,0017	**619/4**
	12	4	0,806	0,28	0,012	120 000	75 000	0,0021	**604**
	13	5	0,936	0,29	0,012	110 000	67 000	0,0031	**624**
	16	5	1,11	0,38	0,016	95 000	60 000	0,0054	**634**
5	11	3	0,637	0,255	0,011	120 000	75 000	0,0012	**618/5**
	13	4	0,884	0,34	0,014	110 000	67 000	0,0025	**619/5**
	16	5	1,14	0,38	0,016	95 000	60 000	0,0050	* **625**
	19	6	2,34	0,95	0,04	80 000	50 000	0,0090	* **635**
6	13	3,5	0,884	0,345	0,015	110 000	67 000	0,0020	**618/6**
	15	5	1,24	0,475	0,02	100 000	63 000	0,0039	**619/6**
	19	6	2,34	0,95	0,04	80 000	50 000	0,0084	* **626**
7	14	3,5	0,956	0,4	0,017	100 000	63 000	0,0022	**618/7**
	17	5	1,48	0,56	0,024	90 000	56 000	0,0049	**619/7**
	19	6	2,34	0,95	0,04	85 000	53 000	0,0075	* **607**
	22	7	3,45	1,37	0,057	70 000	45 000	0,013	* **627**
8	16	4	1,33	0,57	0,024	90 000	56 000	0,0030	**618/8**
	19	6	1,9	0,735	0,031	80 000	50 000	0,0071	**619/8**
	22	7	3,45	1,37	0,057	75 000	48 000	0,012	* **608**
	24	8	3,9	1,66	0,071	63 000	40 000	0,017	* **628**
9	17	4	1,43	0,64	0,027	85 000	53 000	0,0034	**618/9**
	20	6	2,08	0,865	0,036	80 000	48 000	0,0076	**619/9**
	24	7	3,9	1,66	0,071	70 000	43 000	0,014	* **609**
	26	8	4,75	1,96	0,083	60 000	38 000	0,020	* **629**
10	19	5	1,38	0,585	0,025	80 000	48 000	0,0055	**61800**
	22	6	2,08	0,85	0,036	75 000	45 000	0,010	**61900**
	26	8	4,75	1,96	0,083	67 000	40 000	0,019	* **6000**
	28	8	4,62	1,96	0,083	63 000	40 000	0,022	**16100**
	30	9	5,4	2,36	0,1	56 000	34 000	0,032	* **6200**
	35	11	8,52	3,4	0,143	50 000	32 000	0,053	* **6300**

* SKF Explorer bearing

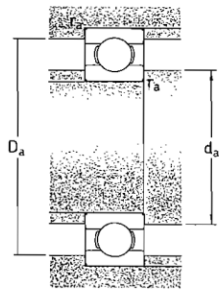
Dimensions					Abutment and fillet dimensions			Calculation factors	
d	d_1 ~	D_1 ~	D_2 ~	$r_{1,2}$ min	d_a min	D_a max	r_a max	k_r	f_0
mm					mm			–	
3	5,2	7,5	8,2	0,15	4,2	8,8	0,1	0,025	7,5
4	5,2	7,5	–	0,1	4,6	8,4	0,1	0,015	10
	5,9	9	9,8	0,15	4,8	10,2	0,1	0,02	9,9
	6,1	9	–	0,2	5,4	10,6	0,2	0,025	10
	6,7	10,3	11,2	0,2	5,8	11,2	0,2	0,025	10
	8,4	12	13,3	0,3	6,4	13,6	0,3	0,03	8,4
5	6,8	9,3	–	0,15	5,8	10,2	0,1	0,015	11
	7,6	10,8	11,4	0,2	6,4	11,6	0,2	0,02	11
	8,4	12	13,3	0,3	7,4	13,6	0,3	0,025	8,4
	10,7	15,3	16,5	0,3	7,4	16,6	0,3	0,03	13
6	7,9	11,2	–	0,15	6,8	12,2	0,1	0,015	11
	8,6	12,4	13,3	0,2	7,4	13,6	0,2	0,02	10
	11,1	15,2	16,5	0,3	8,4	16,6	0,3	0,025	13
7	8,9	12,2	–	0,15	7,8	13,2	0,1	0,015	11
	9,8	14,2	15,2	0,3	9	15	0,3	0,02	10
	11,1	15,2	16,5	0,3	9	17	0,3	0,025	13
	12,2	17,6	19,2	0,3	9,4	19,6	0,3	0,025	12
8	10,1	14	–	0,2	9,4	14,6	0,2	0,015	11
	11,1	16,1	19	0,3	10	17	0,3	0,02	10
	12,1	17,6	19,2	0,3	10	20	0,3	0,025	12
	14,5	19,8	20,6	0,3	10,4	21,6	0,3	0,025	13
9	11,1	15	–	0,2	10,4	15,6	0,2	0,015	11
	12	17	17,9	0,3	11	18	0,3	0,02	11
	14,4	19,8	21,2	0,3	11	22	0,3	0,025	13
	14,8	21,2	22,6	0,3	11,4	23,6	0,3	0,025	12
10	12,6	16,4	–	0,3	12	17	0,3	0,015	9,4
	13	18,1	19	0,3	12	20	0,3	0,02	9,3
	14,8	21,2	22,6	0,3	12	24	0,3	0,025	12
	16,7	23,4	24,8	0,6	14,2	23,8	0,3	0,025	13
	17	23,2	24,8	0,6	14,2	25,8	0,6	0,025	13
	17,5	26,9	28,7	0,6	14,2	30,8	0,6	0,03	11

Single row deep groove ball bearings
d **12 – 22** mm



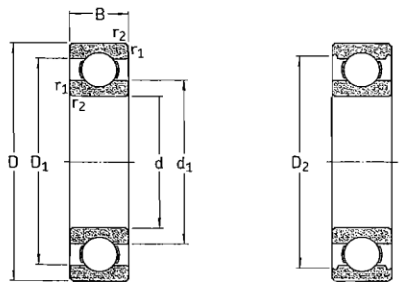
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designation
d	D	B	C	C_0	P_u				
mm			kN		kN	r/min		kg	–
12	21	5	1,43	0,67	0,028	70 000	43 000	0,0063	**61801**
	24	6	2,25	0,98	0,043	67 000	40 000	0,011	**61901**
	28	8	5,4	2,36	0,10	60 000	38 000	0,022	**★ 6001**
	30	8	5,07	2,36	0,10	56 000	34 000	0,023	**16101**
	32	10	7,28	3,1	0,132	50 000	32 000	0,037	**★ 6201**
	37	12	10,1	4,15	0,176	45 000	28 000	0,060	**★ 6301**
15	24	5	1,56	0,8	0,034	60 000	38 000	0,0074	**61802**
	28	7	4,36	2,24	0,095	56 000	34 000	0,016	**61902**
	32	8	5,85	2,85	0,12	50 000	32 000	0,025	**★ 16002**
	32	9	5,85	2,85	0,12	50 000	32 000	0,030	**★ 6002**
	35	11	8,06	3,75	0,16	43 000	28 000	0,045	**★ 6202**
	42	13	11,9	5,4	0,228	38 000	24 000	0,082	**★ 6302**
17	26	5	1,68	0,93	0,039	56 000	34 000	0,0082	**61803**
	30	7	4,62	2,55	0,108	50 000	32 000	0,018	**61903**
	35	8	6,37	3,25	0,137	45 000	28 000	0,032	**★ 16003**
	35	10	6,37	3,25	0,137	45 000	28 000	0,039	**★ 6003**
	40	9	9,56	4,75	0,2	38 000	24 000	0,048	**98203**
	40	12	9,95	4,75	0,2	38 000	24 000	0,065	**★ 6203**
	40	12	11,4	5,4	0,228	38 000	24 000	0,064	**6203 ETN9**
	47	14	14,3	6,55	0,275	34 000	22 000	0,12	**★ 6303**
	62	17	22,9	10,8	0,455	28 000	18 000	0,27	**6403**
20	32	7	4,03	2,32	0,104	45 000	28 000	0,018	**61804**
	37	9	6,37	3,65	0,156	43 000	26 000	0,038	**61904**
	42	8	7,28	4,05	0,173	38 000	24 000	0,050	**★ 16004**
	42	9	7,93	4,5	0,19	38 000	24 000	0,051	**98204 Y**
	42	12	9,95	5	0,212	38 000	24 000	0,069	**★ 6004**
	47	14	13,5	6,55	0,28	32 000	20 000	0,11	**★ 6204**
	47	14	15,6	7,65	0,325	32 000	20 000	0,096	**6204 ETN9**
	52	15	16,8	7,8	0,335	30 000	19 000	0,14	**★ 6304**
	52	15	18,2	9	0,38	30 000	19 000	0,14	**6304 ETN9**
	72	19	30,7	15	0,64	24 000	15 000	0,40	**6404**
22	50	14	14	7,65	0,325	30 000	19 000	0,12	**62/22**
	56	16	18,6	9,3	0,39	28 000	18 000	0,18	**63/22**

★ SKF Explorer bearing



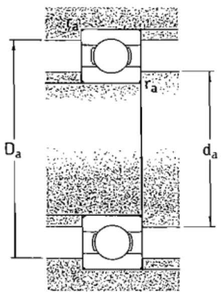
Dimensions					Abutment and fillet dimensions			Calculation factors	
d	d_1 ~	D_1 ~	D_2 ~	$r_{1,2}$ min	d_a min	D_a max	r_a max	k_r	f_0
mm					mm			–	
12	15	18,2	–	0,3	14	19	0,3	0,015	9,7
	15,5	20,6	21,4	0,3	14	22	0,3	0,02	9,7
	17	23,2	24,8	0,3	14	26	0,3	0,025	13
	16,7	23,4	24,8	0,3	14,4	27,6	0,3	0,025	13
	18,5	25,7	27,4	0,6	16,2	27,8	0,6	0,025	12
	19,5	29,5	31,5	1	17,6	31,4	1	0,03	11
15	17,9	21,1	–	0,3	17	22	0,3	0,015	10
	18,4	24,7	25,8	0,3	17	26	0,3	0,02	14
	20,2	27	28,2	0,3	17	30	0,3	0,02	14
	20,5	26,7	28,2	0,3	17	30	0,3	0,025	14
	21,7	29	30,4	0,6	19,2	30,8	0,6	0,025	13
	23,7	33,7	36,3	1	20,6	36,4	1	0,03	12
17	20,2	23,2	–	0,3	19	24	0,3	0,015	10
	20,4	26,7	27,8	0,3	19	28	0,3	0,02	15
	22,7	29,5	31,2	0,3	19	33	0,3	0,02	14
	23	29,2	31,4	0,3	19	33	0,3	0,025	14
	24,5	32,7	–	0,6	21,2	35,8	0,6	0,025	13
	24,5	32,7	35	0,6	21,2	35,8	0,6	0,025	13
	23,9	33,5	–	0,6	21,2	35,8	0,6	0,03	12
	26,5	37,4	39,7	1	22,6	41,4	1	0,03	12
	32,4	46,6	–	1,1	23,5	55,5	1	0,035	11
20	24	28,3	–	0,3	22	30	0,3	0,015	15
	25,6	31,4	32,8	0,3	22	35	0,3	0,02	15
	27,3	34,6	–	0,3	22	40	0,3	0,02	15
	27,4	36	36,2	0,6	23,2	38,8	0,6	0,025	14
	27,2	34,8	37,2	0,6	23,2	38,8	0,6	0,025	14
	28,8	38,5	40,6	1	25,6	41,4	1	0,025	13
	28,2	39,6	–	1	25,6	41,4	1	0,025	12
	30,4	41,6	44,8	1,1	27	45	1	0,03	12
	30,2	42,6	–	1,1	27	45	1	0,03	12
	37,1	54,8	–	1,1	29	63	1	0,035	11
22	32,2	41,8	44	1	27,6	44,4	1	0,025	14
	32,9	45,3	–	1,1	29	47	1	0,03	12

Single row deep groove ball bearings
d 25 – 35 mm



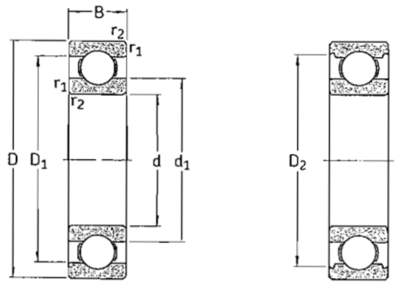
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designation
d	D	B	C	C_0	P_u				
mm			kN		kN	r/min		kg	–
25	37	7	4,36	2,6	0,125	38 000	24 000	0,022	61805
	42	9	7,02	4,3	0,193	36 000	22 000	0,045	61905
	47	8	8,06	4,75	0,212	32 000	20 000	0,060	* 16005
	47	12	11,9	6,55	0,275	32 000	20 000	0,080	* 6005
	52	9	10,6	6,55	0,28	28 000	18 000	0,078	98205
	52	15	14,8	7,8	0,335	28 000	18 000	0,13	* 6205
	52	15	17,8	9,8	0,40	28 000	18 000	0,12	6205 ETN9
	62	17	23,4	11,6	0,49	24 000	16 000	0,23	* 6305
	62	17	26	13,4	0,57	24 000	16 000	0,21	6305 ETN9
	80	21	35,8	19,3	0,82	20 000	13 000	0,53	6405
28	58	16	16,8	9,5	0,405	26 000	16 000	0,18	62/28
	68	18	25,1	13,7	0,585	22 000	14 000	0,29	63/28
30	42	7	4,49	2,9	0,146	32 000	20 000	0,027	61806
	47	9	7,28	4,55	0,212	30 000	19 000	0,051	61906
	55	9	11,9	7,35	0,31	28 000	17 000	0,085	* 16006
	55	13	13,8	8,3	0,355	28 000	17 000	0,12	* 6006
	62	10	15,9	10,2	0,44	22 000	14 000	0,12	98206
	62	16	20,3	11,2	0,48	24 000	15 000	0,20	* 6206
	62	16	23,4	12,9	0,54	24 000	15 000	0,19	6206 ETN9
	72	19	29,6	16	0,67	20 000	13 000	0,35	* 6306
	72	19	32,5	17,3	0,74	22 000	14 000	0,33	6306 ETN9
	90	23	43,6	23,6	1,00	18 000	11 000	0,74	6406
35	47	7	4,75	3,2	0,17	28 000	18 000	0,030	61807
	55	10	9,56	6,8	0,29	26 000	16 000	0,080	61907
	62	9	13	8,15	0,38	24 000	15 000	0,11	* 16007
	62	14	16,8	10,2	0,44	24 000	15 000	0,16	* 6007
	72	17	27	15,3	0,66	20 000	13 000	0,29	* 6207
	72	17	31,2	17,6	0,75	20 000	13 000	0,27	6207 ETN9
	80	21	35,1	19	0,82	19 000	12 000	0,46	* 6307
	100	25	55,3	31	1,29	16 000	10 000	0,95	6407

* SKF Explorer bearing



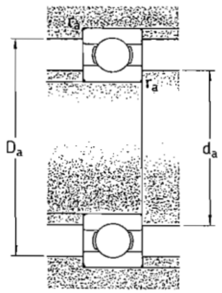
Dimensions					Abutment and fillet dimensions			Calculation factors	
d	d_1 ~	D_1 ~	D_2 ~	$r_{1,2}$ min	d_a min	D_a max	r_a max	k_r	f_0
mm					mm			–	
25	28,5	33,3	–	0,3	27	35	0,3	0,015	14
	30,2	36,8	37,8	0,3	27	40	0,3	0,02	15
	33,3	40,7	–	0,3	27	45	0,3	0,02	15
	32	40	42,2	0,6	28,2	43,8	0,6	0,025	14
	34,5	44	–	0,6	28,2	48,8	0,6	0,025	15
	34,4	44	46,3	1	30,6	46,4	1	0,025	14
	33,1	44,5	–	1	30,6	46,4	1	0,025	13
	36,6	50,4	52,7	1,1	32	55	1	0,03	12
	36,4	51,7	–	1,1	32	55	1	0,03	12
	45,4	62,9	–	1,5	34	71	1,5	0,035	12
28	37	49,2	–	1	33,6	52,4	1	0,025	14
	41,7	56	–	1,1	35	61	1	0,03	13
30	33,7	38,5	–	0,3	32	40	0,3	0,015	14
	35,2	41,8	42,8	0,3	32	45	0,3	0,02	14
	37,7	47,3	–	0,3	32	53	0,3	0,02	15
	38,2	46,8	49	1	34,6	50,4	1	0,025	15
	42,9	54,4	–	0,6	33,2	58,8	0,6	0,025	14
	40,4	51,6	54,1	1	35,6	56,4	1	0,025	14
	39,5	52,9	–	1	35,6	56,4	1	0,025	13
	44,6	59,1	61,9	1,1	37	65	1	0,03	13
	42,5	59,7	–	1,1	37	65	1	0,03	12
	50,3	69,7	–	1,5	41	79	1,5	0,035	12
35	38,7	43,5	–	0,3	37	45	0,3	0,015	14
	41,6	48,4	–	0,6	38,2	51,8	0,6	0,02	14
	44,1	53	–	0,3	37	60	0,3	0,02	14
	43,8	53,3	55,6	1	39,6	57,4	1	0,025	15
	46,9	60	62,7	1,1	42	65	1	0,025	14
	46,1	61,7	–	1,1	42	65	1	0,025	13
	49,6	65,4	69,2	1,5	44	71	1,5	0,03	13
	57,4	79,5	–	1,5	46	89	1,5	0,035	12

Single row deep groove ball bearings
d **40 – 60** mm



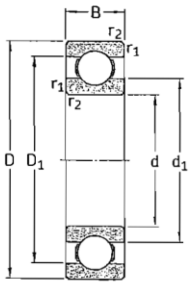
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designation
d	D	B	C	C0	Pu				
mm			kN		kN	r/min		kg	–
40	52	7	4,94	3,45	0,19	26 000	16 000	0,034	**61808**
	62	12	13,8	10	0,43	24 000	14 000	0,12	**61908**
	68	9	13,8	9,15	0,44	22 000	14 000	0,13	* **16008**
	68	15	17,8	11,6	0,49	22 000	14 000	0,19	* **6008**
	80	18	32,5	19	0,80	18 000	11 000	0,37	* **6208**
	80	18	35,8	20,8	0,88	18 000	11 000	0,34	**6208 ETN9**
	90	23	42,3	24	1,02	17 000	11 000	0,63	* **6308**
	110	27	63,7	36,5	1,53	14 000	9 000	1,25	**6408**
45	58	7	6,63	6,1	0,26	22 000	14 000	0,040	**61809**
	68	12	14	10,8	0,47	20 000	13 000	0,14	**61909**
	75	10	16,5	10,8	0,52	20 000	12 000	0,17	* **16009**
	75	16	22,1	14,6	0,64	20 000	12 000	0,25	* **6009**
	85	19	35,1	21,6	0,92	17 000	11 000	0,41	* **6209**
	100	25	55,3	31,5	1,34	15 000	9 500	0,83	* **6309**
	120	29	76,1	45	1,90	13 000	8 500	1,55	**6409**
50	65	7	6,76	6,8	0,285	20 000	13 000	0,052	**61810**
	72	12	14,6	11,8	0,50	19 000	12 000	0,14	**61910**
	80	10	16,8	11,4	0,56	18 000	11 000	0,18	* **16010**
	80	16	22,9	16	0,71	18 000	11 000	0,26	* **6010**
	90	20	37,1	23,2	0,98	15 000	10 000	0,46	* **6210**
	110	27	65	38	1,6	13 000	8 500	1,05	* **6310**
	130	31	87,1	52	2,2	12 000	7 500	1,9	**6410**
55	72	9	9,04	8,8	0,38	19 000	12 000	0,083	**61811**
	80	13	16,5	14	0,60	17 000	11 000	0,19	**61911**
	90	11	20,3	14	0,70	16 000	10 000	0,26	* **16011**
	90	18	29,6	21,2	0,90	16 000	10 000	0,39	* **6011**
	100	21	46,2	29	1,25	14 000	9 000	0,61	* **6211**
	120	29	74,1	45	1,90	12 000	8 000	1,35	* **6311**
	140	33	99,5	62	2,60	11 000	7 000	2,3	**6411**
60	78	10	11,9	11,4	0,49	17 000	11 000	0,11	**61812**
	85	13	16,5	14,3	0,60	16 000	10 000	0,20	**61912**
	95	11	20,8	15	0,74	15 000	9 500	0,28	* **16012**
	95	18	30,7	23,2	0,98	15 000	9 500	0,42	* **6012**
	110	22	55,3	36	1,53	13 000	8 000	0,78	* **6212**
	130	31	85,2	52	2,20	11 000	7 000	1,7	* **6312**
	150	35	108	69,5	2,90	10 000	6 300	2,75	**6412**

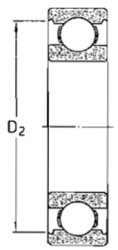
* SKF Explorer bearing



Dimensions					Abutment and fillet dimensions			Calculation factors	
d	d1 ~	D1 ~	D2 ~	r1,2 min	da min	Da max	ra max	kr	f0
mm					mm			–	
40	43,7	48,5	–	0,3	42	50	0,3	0,015	14
	46,9	55,1	–	0,6	43,2	58,8	0,6	0,02	16
	49,4	58,6	–	0,3	42	66	0,3	0,02	14
	49,3	58,8	61,1	1	44,6	63,4	1	0,025	15
	52,6	67,4	69,8	1,1	47	73	1	0,025	14
	52	68,8	–	1,1	47	73	1	0,025	13
	56,1	73,8	77,7	1,5	49	81	1,5	0,03	13
	62,8	87	–	2	53	97	2	0,035	12
45	49,1	53,9	–	0,3	47	56	0,3	0,015	17
	52,4	60,6	–	0,6	48,2	64,8	0,6	0,02	16
	55	65,4	–	0,6	48,2	71,8	0,6	0,02	14
	54,8	65,3	67,8	1	50,8	69,2	1	0,025	15
	57,6	72,4	75,2	1,1	52	78	1	0,025	14
	62,2	82,7	86,7	1,5	54	91	1,5	0,03	13
	68,9	95,8	–	2	58	107	2	0,035	12
50	55,1	59,9	–	0,3	52	63	0,3	0,015	17
	56,9	65,1	–	0,6	53,2	68,8	0,6	0,02	16
	60	70	–	0,6	53,2	76,8	0,6	0,02	14
	59,8	70,3	72,8	1	54,6	75,4	1	0,025	15
	62,5	77,4	81,6	1,1	57	83	1	0,025	14
	68,8	91,1	95,2	2	61	99	2	0,03	13
	75,5	104	–	2,1	64	116	2	0,035	12
55	60,6	66,4	–	0,3	57	70	0,3	0,015	17
	63,2	71,8	–	1	59,6	75,4	1	0,02	16
	67	78,1	–	0,6	58,2	86,8	0,6	0,02	15
	66,3	78,7	81,5	1,1	61	84	1	0,025	15
	69,1	85,8	89,4	1,5	64	91	1,5	0,025	14
	75,3	99,5	104	2	66	109	2	0,03	13
	81,6	113	–	2,1	69	126	2	0,035	12
60	65,6	72,4	–	0,3	62	76	0,3	0,015	17
	68,2	76,8	–	1	64,6	80,4	1	0,02	16
	72	83	–	0,6	63,2	91,8	0,6	0,02	14
	71,3	83,7	86,5	1,1	66	89	1	0,025	16
	75,5	94,6	98	1,5	69	101	1,5	0,025	14
	81,9	108	112	2,1	72	118	2	0,03	13
	88,1	122	–	2,1	74	136	2	0,035	12

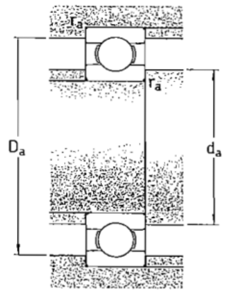
Single row deep groove ball bearings
d **65 – 85** mm





Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designation
d	D	B	C	C_0	P_u				
mm			kN		kN	r/min		kg	–
65	85	10	12,4	12,7	0,54	16 000	10 000	0,13	**61813**
	90	13	17,4	16	0,68	15 000	9 500	0,22	**61913**
	100	11	22,5	16,6	0,83	14 000	9 000	0,30	* **16013**
	100	18	31,9	25	1,06	14 000	9 000	0,44	* **6013**
	120	23	58,5	40,5	1,73	12 000	7 500	0,99	* **6213**
	140	33	97,5	60	2,5	10 000	6 700	2,10	* **6313**
	160	37	119	78	3,15	9 500	6 000	3,30	**6413**
70	90	10	12,4	13,2	0,56	15 000	9 000	0,14	**61814**
	100	16	23,8	21,2	0,9	14 000	8 500	0,35	**61914**
	110	13	29,1	25	1,06	13 000	8 000	0,43	* **16014**
	110	20	39,7	31	1,32	13 000	8 000	0,60	* **6014**
	125	24	63,7	45	1,9	11 000	7 000	1,05	* **6214**
	150	35	111	68	2,75	9 500	6 300	2,50	* **6314**
	180	42	143	104	3,9	8 500	5 300	4,85	**6414**
75	95	10	12,7	14,3	0,61	14 000	8 500	0,15	**61815**
	105	16	24,2	19,3	0,965	13 000	8 000	0,37	**61915**
	110	12	28,6	27	1,14	13 000	8 000	0,38	**16115**
	115	13	30,2	27	1,14	12 000	7 500	0,46	* **16015**
	115	20	41,6	33,5	1,43	12 000	7 500	0,64	* **6015**
	130	25	68,9	49	2,04	10 000	6 700	1,20	* **6215**
	160	37	119	76,5	3	9 000	5 600	3,00	* **6315**
	190	45	153	114	4,15	8 000	5 000	6,80	**6415**
80	100	10	13	15	0,64	13 000	8 000	0,15	**61816**
	110	16	25,1	20,4	1,02	12 000	7 500	0,40	**61916**
	125	14	35,1	31,5	1,32	11 000	7 000	0,60	* **16016**
	125	22	49,4	40	1,66	11 000	7 000	0,85	* **6016**
	140	26	72,8	55	2,2	9 500	6 000	1,40	* **6216**
	170	39	130	86,5	3,25	8 500	5 300	3,60	* **6316**
	200	48	163	125	4,5	7 500	4 800	8,00	**6416**
85	110	13	19,5	20,8	0,88	12 000	7 500	0,27	**61817**
	120	18	31,9	30	1,25	11 000	7 000	0,55	**61917**
	130	14	35,8	33,5	1,37	11 000	6 700	0,63	* **16017**
	130	22	52	43	1,76	11 000	6 700	0,89	* **6017**
	150	28	87,1	64	2,5	9 000	5 600	1,80	* **6217**
	180	41	140	96,5	3,55	8 000	5 000	4,25	* **6317**
	210	52	174	137	4,75	7 000	4 500	9,50	**6417**

* SKF Explorer bearing



Dimensions					Abutment and fillet dimensions			Calculation factors	
d	d_1 ~	D_1 ~	D_2 ~	$r_{1,2}$ min	d_a min	D_a max	r_a max	k_r	f_0
mm					mm			–	
65	71,6	78,4	–	0,6	68,2	81,8	0,6	0,015	17
	73,2	81,8	–	1	69,6	85,4	1	0,02	17
	76,5	88,4	–	0,6	68,2	96,8	0,6	0,02	16
	76,3	88,7	91,5	1,1	71	94	1	0,025	16
	83,3	102	106	1,5	74	111	1,5	0,025	15
	88,4	116	121	2,1	77	128	2	0,03	13
	94	131	–	2,1	79	146	2	0,035	12
70	76,6	83,4	–	0,6	73,2	86,8	0,6	0,015	17
	79,7	90,3	–	1	74,6	95,4	1	0,02	16
	83,3	96,8	–	0,6	73,2	106	0,6	0,02	16
	82,9	97,2	99,9	1,1	76	104	1	0,025	16
	87,1	108	111	1,5	79	116	1,5	0,025	15
	95	125	130	2,1	82	138	2	0,03	13
	104	146	–	3	86	164	2,5	0,035	12
75	81,6	88,4	–	0,6	78,2	91,8	0,6	0,015	17
	84,7	95,3	–	1	79,6	100	1	0,02	14
	88,3	102	–	0,6	77	108	0,3	0,02	16
	88,3	102	–	0,6	78,2	111	0,6	0,02	16
	87,9	102	105	1,1	81	109	1	0,025	16
	92,1	113	117	1,5	84	121	1,5	0,025	15
	101	133	138	2,1	87	148	2	0,03	13
	110	154	–	3	91	174	2,5	0,035	12
80	86,6	93,4	–	0,6	83,2	96,8	0,6	0,015	17
	89,8	100	102	1	84,6	105	1	0,02	14
	95,3	110	–	0,6	83,2	121	0,6	0,02	16
	94,4	111	114	1,1	86	119	1	0,025	16
	101	122	127	2	91	129	2	0,025	15
	108	142	147	2,1	92	158	2	0,03	13
	117	163	–	3	96	184	2,5	0,035	12
85	93,2	102	–	1	89,6	105	1	0,015	17
	96,4	109	–	1,1	91	114	1	0,02	16
	100	115	–	0,6	88,2	126	0,6	0,02	16
	99,4	116	119	1,1	92	123	1	0,025	16
	106	130	134	2	96	139	2	0,025	15
	115	151	155	3	99	166	2,5	0,03	13
	123	171	–	4	105	190	3	0,035	12

Load carrying capacity of bearing pairs

The values for basic load ratings and fatigue load limits provided in the product table apply to single bearings. For bearing pairs mounted immediately adjacent to each other the following values apply

- basic dynamic load rating for standard bearings in all arrangements and for SKF Explorer bearings in back-to-back or face-to-face arrangement
  $C = 1,62 \times C_{\text{single bearing}}$
- basic dynamic load rating for SKF Explorer bearings in tandem arrangement
  $C = 2 \times C_{\text{single bearing}}$
- basic static load rating
  $C_0 = 2 \times C_{0\ \text{single bearing}}$
- fatigue load limit
  $P_u = 2 \times P_{u\ \text{single bearing}}$

Minimum load

In order to provide satisfactory operation, angular contact ball bearings, like all ball and roller bearings, must always be subjected to a given minimum load, particularly if they are to operate at high speeds or are subjected to high accelerations or rapid changes in the direction of load. Under such conditions, the inertia forces of the balls and cage, and the friction in the lubricant, have a detrimental influence on the rolling conditions in the bearing arrangement and may cause damaging sliding movements to occur between the balls and raceways.

The requisite minimum load to be applied to single bearings and bearing pairs arranged in tandem can be estimated using

$$F_{am} = k_a \frac{C_0}{1\,000} \left(\frac{n\, d_m}{100\,000} \right)^2$$

and for bearing pairs arranged back-to-back or face-to-face from

$$F_{rm} = k_r \left(\frac{\nu\, n}{1\,000} \right)^{2/3} \left(\frac{d_m}{100} \right)^2$$

Table 3

Minimum load factors

Bearing series	Minimum load factors k_a	k_r
72 BE	1,4	0,095
72 B	1,2	0,08
73 BE	1,6	0,1
73 B	1,4	0,09

where

F_{am} = minimum axial load, kN
F_{rm} = minimum radial load, kN
C_0 = basic static load rating of single bearing, or bearing pair, kN (→ product table)
k_a = minimum axial load factor according to **table 3**
k_r = minimum radial load factor according to **table 3**
ν = oil viscosity at operating temperature, mm^2/s
n = rotational speed, r/min
d_m = bearing mean diameter = 0,5 (d + D), mm

When starting up at low temperatures or when the lubricant is highly viscous, even greater minimum loads may be required. The weight of the components supported by the bearing, together with external forces, generally exceeds the requisite minimum load. If this is not the case, the angular contact ball bearing must be subjected to an additional load. Single bearings and bearing pairs arranged in tandem can be axially preloaded by adjusting the inner or outer rings against each other, or by using springs.

Equivalent dynamic bearing load

For single bearings and bearings paired in tandem

$P = F_r$	when $F_a/F_r \le 1,14$
$P = 0,35\, F_r + 0,57\, F_a$	when $F_a/F_r > 1,14$

When determining the axial force F_a, reference should be made to the section "Determining axial force for bearings mounted singly or paired in tandem".

For bearings mounted in pairs, arranged back-to-back or face-to-face

$P = F_r + 0,55\, F_a$	when $F_a/F_r \le 1,14$
$P = 0,57\, F_r + 0,93\, F_a$	when $F_a/F_r > 1,14$

F_r and F_a are the forces acting on the bearing pair.

Equivalent static bearing load

For single bearings and bearings paired in tandem

$$P_0 = 0,5\, F_r + 0,26\, F_a$$

If $P_0 < F_r$, then $P_0 = F_r$ should be used. When determining the axial force F_a reference should be made to the section "Determining axial force for bearings mounted singly or paired in tandem".

For bearings mounted in pairs, arranged back-to-back or face-to-face

$$P_0 = F_r + 0,52\, F_a$$

F_r and F_a are the forces acting on the bearing pair.

Determining axial force for bearings mounted singly or paired in tandem

When a radial load is applied, the load is transmitted from one raceway to the other at an angle to the bearing axis and an internal axial force will be induced in single row angular contact ball bearings. This must be considered when calculating the equivalent bearing loads for bearing arrangements consisting of two single bearings and/or bearing pairs arranged in tandem.

The necessary equations are provided in **table 4, page 416**, for the various bearing arrangements and load cases. The equations are only valid if the bearings are adjusted against each other to practically zero clearance, but without any preload. In the arrangements shown, bearing A is subjected to a radial load F_{rA} and bearing B to a radial load F_{rB}. Both F_{rA} and F_{rB} are always considered positive, even when they act in the direction opposite to that shown in the figures. The radial loads act at the pressure centres of the bearings (see dimension a in the product table).

Variable R

The variable R from **table 4** takes into account the contact conditions inside the bearing. The values for R can be obtained from **diagram 1, page 417**, as a function of the ratio K_a/C. K_a is the external axial load acting on the shaft or on the housing and C is the basic dynamic load rating of the bearing, which must accommodate the external axial load. For $K_a = 0$ use R = 1.

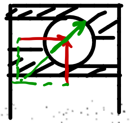
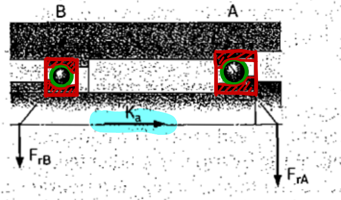
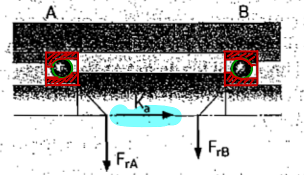
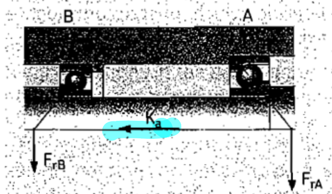
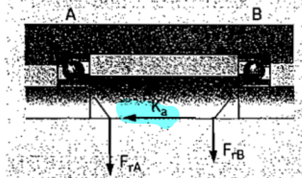


Table 4

Axial loading of bearing arrangements incorporating two single row B or BE design angular contact ball bearings and/or bearing pairs in tandem

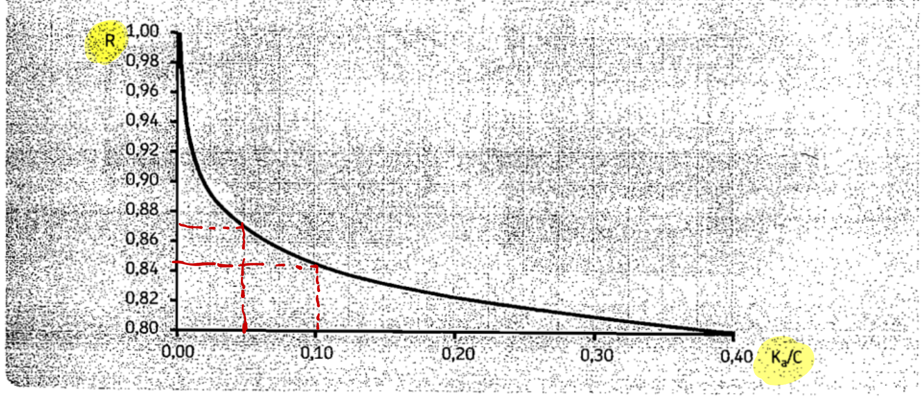
Bearing arrangement	Load case	Axial forces	
Back-to-back 	Case 1a $F_{rA} \geq F_{rB}$ $K_a \geq 0$	$F_{aA} = R\,F_{rA}$	$F_{aB} = F_{aA} + K_a$
	Case 1b $F_{rA} < F_{rB}$ $K_a \geq R\,(F_{rB} - F_{rA})$	$F_{aA} = R\,F_{rA}$	$F_{aB} = F_{aA} + K_a$
Face-to-face 	Case 1c $F_{rA} < F_{rB}$ $K_a < R\,(F_{rB} - F_{rA})$	$F_{aA} = F_{aB} - K_a$	$F_{aB} = R\,F_{rB}$
Back-to-back 	Case 2a $F_{rA} \leq F_{rB}$ $K_a \geq 0$	$F_{aA} = F_{aB} + K_a$	$F_{aB} = R\,F_{rB}$
	Case 2b $F_{rA} > F_{rB}$ $K_a \geq R\,(F_{rA} - F_{rB})$	$F_{aA} = F_{aB} + K_a$	$F_{aB} = R\,F_{rB}$
Face-to-face 	Case 2c $F_{rA} > F_{rB}$ $K_a < R\,(F_{rA} - F_{rB})$	$F_{aA} = R\,F_{rA}$	$F_{aB} = F_{aA} - K_a$

Supplementary designations

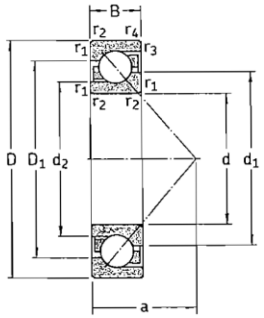
The designation suffixes used to identify certain features of SKF single row angular contact ball bearings are explained in the following.

A	30° contact angle
AC	25° contact angle
B	40° contact angle
CA	Bearing for universal matching. Two bearings arranged back-to-back or face-to-face will have an axial internal clearance smaller than Normal (CB) before mounting
CB	Bearing for universal matching. Two bearings arranged back-to-back or face-to-face willl have a Normal axial internal clearance before mounting
CC	Bearing for universal matching. Two bearings arranged back-to-back or face-to-face will have an axial internal clearance greater than Normal (CB) before mounting
DB	Two bearings matched back-to-back
DF	Two bearings matched face-to-face
DT	Two bearings matched in tandem
E	Optimized internal design
F	Machined window-type steel cage, ball centred
GA	Bearing for universal matching. Two bearings arranged back-to-back or face-to-face will have a light preload before mounting
GB	Bearing for universal matching. Two bearings arranged back-to-back or face-to-face will have a moderate preload before mounting
GC	Bearing for universal matching. Two bearings arranged back-to-back or face-to-face will have a heavy preload before mounting
J	Pressed window-type steel cage, ball centred
M	Machined window-type brass cage, ball centred, different designs are identified by a figure, e.g. M1
N1	One locating slot (notch) in the large outer ring side face
N2	Two locating slots (notches), 180° apart, in the large outer ring side face
P	Injection moulded window-type cage of glass fibre reinforced polyamide 6,6, ball centred
PH	Injection moulded window-type cage of glass fibre reinforced polyetherether-ketone (PEEK), ball centred
P5	Dimensional and running accuracy to ISO tolerance class 5
P6	Dimensional and running accuracy to ISO tolerance class 6
W64	Solid Oil filling
Y	Pressed window-type brass cage, ball centred

Diagram 1



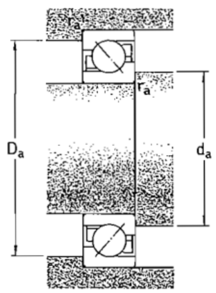
Single row angular contact ball bearings
d **10 – 25** mm

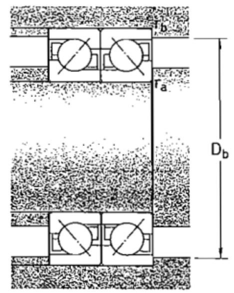


Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designations[1)] Universally matchable bearing	Basic design bearing
d	D	B	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	
10	30	9	7,02	3,35	0,14	30 000	30 000	0,030	**7200 BECBP**	**7200 BEP**
12	32	10	7,61	3,8	0,16	26 000	26 000	0,036	**7201 BECBP**	**7201 BEP**
	37	12	10,6	5	0,208	24 000	24 000	0,063	–	**7301 BEP**
15	35	11	9,5	5,1	0,216	26 000	26 000	0,045	* **7202 BECBP**	–
	35	11	8,84	4,8	0,204	24 000	24 000	0,045	–	**7202 BEP**
	42	13	13	6,7	0,28	20 000	20 000	0,081	**7302 BECBP**	**7302 BEP**
17	40	12	11	5,85	0,25	22 000	22 000	0,064	* **7203 BECBP**	–
	40	12	10,4	5,5	0,236	20 000	20 000	0,064	–	**7203 BEP**
	40	12	11,1	6,1	0,26	20 000	20 000	0,064	–	**7203 BEY**
	40	12	11	5,85	0,25	22 000	22 000	0,070	* **7203 BECBM**	–
	47	14	15,9	8,3	0,355	19 000	19 000	0,11	**7303 BECBP**	**7303 BEP**
20	47	14	14,3	8,15	0,345	19 000	19 000	0,11	* **7204 BECBP**	–
	47	14	13,3	7,65	0,325	18 000	18 000	0,11	–	**7204 BEP**
	47	14	14	8,3	0,355	18 000	18 000	0,11	**7204 BECBY**	–
	47	14	13,3	7,65	0,325	18 000	19 000	0,11	**7204 BECBM**	–
	52	15	19	10	0,425	18 000	18 000	0,14	* **7304 BECBP**	–
	52	15	17,4	9,5	0,4	16 000	16 000	0,14	–	**7304 BEP**
	52	15	19	10,4	0,44	16 000	16 000	0,15	**7304 BECBY**	**7304 BEY**
	52	15	19	10	0,425	18 000	18 000	0,15	* **7304 BECBM**	–
25	52	15	15,6	10	0,43	17 000	17 000	0,13	* **7205 BECBP**	–
	52	15	14,8	9,3	0,4	15 000	15 000	0,13	–	**7205 BEP**
	52	15	15,6	10,2	0,43	15 000	15 000	0,13	**7205 BECBY**	**7205 BEY**
	52	15	15,6	10	0,43	17 000	17 000	0,14	* **7205 BECBM**	–
	62	17	26,5	15,3	0,655	15 000	15 000	0,23	* **7305 BECBP**	–
	62	17	24,2	14	0,6	14 000	14 000	0,23	–	**7305 BEP**
	62	17	26	15,6	0,655	14 000	14 000	0,24	**7305 BECBY**	**7305 BEY**
	62	17	26,5	15,3	0,655	15 000	15 000	0,24	* **7305 BECBM**	–

* SKF Explorer bearing
1) For available final variants → **matrix 1** on **page 419**

SKF

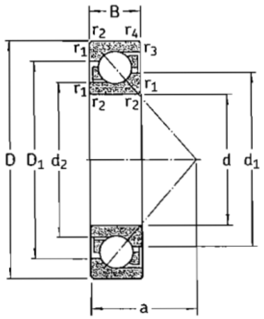


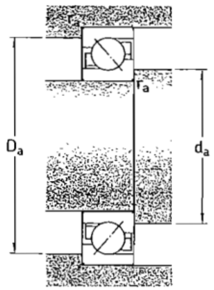


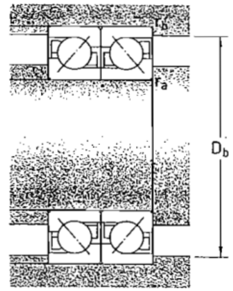
Dimensions							Abutment and fillet dimensions				
d	d_1 ~	d_2 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	D_a max	D_b max	r_a max	r_b max
mm							mm				
10	18,3	14,6	22,9	0,6	0,3	13	14,2	25,8	27,6	0,6	0,3
12	20,2	16,6	25	0,6	0,3	14,4	16,2	27,8	29,6	0,6	0,3
	21,8	17	28,3	1	0,6	16,3	17,6	31,4	32,8	1	0,6
15	22,7	19	27,8	0,6	0,3	16	19,2	30,8	32,6	0,6	0,3
	22,7	19	27,8	0,6	0,3	16	19,2	30,8	32,6	0,6	0,3
	26	20,7	32,6	1	0,6	18,6	20,6	36,4	37,8	1	0,6
17	26,3	21,7	31,2	0,6	0,6	18	21,2	35,8	35,8	0,6	0,6
	26,3	21,7	31,2	0,6	0,6	18	21,2	35,8	35,8	0,6	0,6
	26,3	21,7	31,2	0,6	0,6	18	21,2	35,8	35,8	0,6	0,6
	26,3	21,7	31,2	0,6	0,6	18	21,2	35,8	35,8	0,6	0,6
	28,7	22,8	36,2	1	0,6	20,4	22,6	41,4	42,8	1	0,6
20	30,8	25,9	36,5	1	0,6	21	25,6	41,4	42,8	1	0,6
	30,8	25,9	36,5	1	0,6	21	25,6	41,4	42,8	1	0,6
	30,8	25,9	36,5	1	0,6	21	25,6	41,4	42,8	1	0,6
	30,8	25,9	36,5	1	0,6	21	25,6	41,4	42,8	1	0,6
	33,3	26,8	40,4	1,1	0,6	22,8	27	45	47,8	1	0,6
	33,3	26,8	40,4	1,1	0,6	22,8	27	45	47,8	1	0,6
	33,3	26,8	40,4	1,1	0,6	22,8	27	45	47,8	1	0,6
	33,3	26,8	40,4	1,1	0,6	22,8	27	45	47,8	1	0,6
25	36,1	30,9	41,5	1	0,6	23,7	30,6	46,4	47,8	1	0,6
	36,1	30,9	41,5	1	0,6	23,7	30,6	46,4	47,8	1	0,6
	36,1	30,9	41,5	1	0,6	23,7	30,6	46,4	47,8	1	0,6
	36,1	30,9	41,5	1	0,6	23,7	30,6	46,4	47,8	1	0,6
	39,8	32,4	48,1	1,1	0,6	26,8	32	55	57,8	1	0,6
	39,8	32,4	48,1	1,1	0,6	26,8	32	55	57,8	1	0,6
	39,8	32,4	48,1	1,1	0,6	26,8	32	55	57,8	1	0,6
	39,8	32,4	48,1	1,1	0,6	26,8	32	55	57,8	1	0,6

SKF

Single row angular contact ball bearings
d **30 – 45** mm







Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designations[1)] Universally matchable bearing	Basic design bearing
d	D	B	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	
30	62	16	24	15,6	0,655	14 000	14 000	0,19	★ 7206 BECBP	–
	62	16	22,5	14,3	0,61	13 000	13 000	0,19	–	7206 BEP
	62	16	23,8	15,6	0,655	13 000	13 000	0,21	7206 BECBY	7206 BEY
	62	16	24	15,6	0,655	14 000	14 000	0,21	★ 7206 BECBM	–
	72	19	35,5	21,2	0,9	13 000	13 000	0,33	★ 7306 BECBP	–
	72	19	32,5	19,3	0,815	12 000	12 000	0,33	–	7306 BEP
	72	19	34,5	21,2	0,9	12 000	12 000	0,37	7306 BECBY	7306 BEY
	72	19	35,5	21,2	0,9	13 000	13 000	0,37	★ 7306 BECBM	–
35	72	17	31	20,8	0,88	12 000	12 000	0,28	★ 7207 BECBP	–
	72	17	29,1	19	0,815	11 000	11 000	0,28	–	7207 BEP
	72	17	30,7	20,8	0,88	11 000	11 000	0,30	7207 BECBY	7207 BEY
	72	17	31	20,8	0,88	12 000	12 000	0,30	★ 7207 BECBM	–
	80	21	41,5	26,5	1,14	11 000	11 000	0,45	★ 7307 BECBP	–
	80	21	39	24,5	1,04	10 000	10 000	0,45	–	7307 BEP
	80	21	39	24,5	1,04	10 000	10 000	0,49	7307 BECBY	7307 BEY
	80	21	41,5	26,5	1,14	11 000	11 000	0,49	★ 7307 BECBM	–
40	80	18	36,5	26	1,1	11 000	11 000	0,37	★ 7208 BECBP	–
	80	18	34,5	24	1,02	10 000	10 000	0,37	–	7208 BEP
	80	18	36,4	26	1,1	10 000	10 000	0,38	7208 BECBY	7208 BEY
	80	18	36,5	26	1,1	11 000	11 000	0,39	★ 7208 BECBM	–
	80	18	34,5	24	1,02	10 000	10 000	0,39	–	7208 BEM
	90	23	50	32,5	1,37	10 000	10 000	0,61	★ 7308 BECBP	–
	90	23	46,2	30,5	1,13	9 000	9 000	0,61	–	7308 BEP
	90	23	49,4	33,5	1,4	9 000	9 000	0,64	7308 BECBY	7308 BEY
	90	23	50	32,5	1,37	10 000	10 000	0,68	★ 7308 BECBM	–
45	85	19	38	28,5	1,22	10 000	10 000	0,42	★ 7209 BECBP	–
	85	19	35,8	26	1,12	9 000	9 000	0,42	–	7209 BEP
	85	19	37,7	28	1,2	9 000	9 000	0,43	7209 BECBY	7209 BEY
	85	19	38	28,5	1,22	10 000	10 000	0,44	★ 7209 BECBM	–
	100	25	61	40,5	1,73	9 000	9 000	0,82	★ 7309 BECBP	–
	100	25	55,9	37,5	1,73	8 000	8 000	0,82	–	7309 BEP
	100	25	60,5	41,5	1,73	8 000	8 000	0,86	7309 BECBY	7309 BEY
	100	25	61	40,5	1,73	9 000	9 000	0,90	★ 7309 BECBM	–

★ SKF Explorer bearing
1) For available final variants → **matrix 1 on page 419**

Dimensions							Abutment and fillet dimensions				
d	d_1 ~	d_2 ~	D_1 ~	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a min	D_a max	D_b max	r_a max	r_b max
mm							mm				
30	42,7	36,1	50,1	1	0,6	27,3	35,6	56,4	57,8	1	0,6
	42,7	36,1	50,1	1	0,6	27,3	35,6	56,4	57,8	1	0,6
	42,7	36,1	50,1	1	0,6	27,3	35,6	56,4	57,8	1	0,6
	42,7	36,1	50,1	1	0,6	27,3	35,6	56,4	57,8	1	0,6
	46,6	37,9	56,5	1,1	0,6	31	37	65	67,8	1	0,6
	46,6	37,9	56,5	1,1	0,6	31	37	65	67,8	1	0,6
	46,6	37,9	56,5	1,1	0,6	31	37	65	67,8	1	0,6
	46,6	37,9	56,5	1,1	0,6	31	37	65	67,8	1	0,6
35	49,7	42	58,3	1,1	0,6	31	42	65	67,8	1	0,6
	49,7	42	58,3	1,1	0,6	31	42	65	67,8	1	0,6
	49,7	42	58,3	1,1	0,6	31	42	65	67,8	1	0,6
	49,7	42	58,3	1,1	0,6	31	42	65	67,8	1	0,6
	52,8	43,6	63,3	1,5	1	35	44	71	74,4	1,5	1
	52,8	43,6	63,3	1,5	1	35	44	71	74,4	1,5	1
	52,8	43,6	63,3	1,5	1	35	44	71	74,4	1,5	1
	52,8	43,6	63,3	1,5	1	35	44	71	74,4	1,5	1
40	56,3	48,1	65,6	1,1	0,6	34	47	73	75,8	1	0,6
	56,3	48,1	65,6	1,1	0,6	34	47	73	75,8	1	0,6
	56,3	48,1	65,6	1,1	0,6	34	47	73	75,8	1	0,6
	56,3	48,1	65,6	1,1	0,6	34	47	73	75,8	1	0,6
	56,3	48,1	65,6	1,1	0,6	34	47	73	75,8	1	0,6
	59,7	49,6	71,6	1,5	1	39	49	81	84,4	1,5	1
	59,7	49,6	71,6	1,5	1	39	49	81	84,4	1,5	1
	59,7	49,6	71,6	1,5	1	39	49	81	84,4	1,5	1
	59,7	49,6	71,6	1,5	1	39	49	81	84,4	1,5	1
45	60,9	52,7	70,2	1,1	0,6	37	52	78	80,8	1	0,6
	60,9	52,7	70,2	1,1	0,6	37	52	78	80,8	1	0,6
	60,9	52,7	70,2	1,1	0,6	37	52	78	80,8	1	0,6
	60,9	52,7	70,2	1,1	0,6	37	52	78	80,8	1	0,6
	66,5	55,3	79,8	1,5	1	43	54	91	94,4	1,5	1
	66,5	55,3	79,8	1,5	1	43	54	91	94,4	1,5	1
	66,5	55,3	79,8	1,5	1	43	54	91	94,4	1,5	1
	66,5	55,3	79,8	1,5	1	43	54	91	94,4	1,5	1

Cages

Depending on the bearing series and size, SKF self-aligning ball bearings are fitted as standard with one of the following cages (→ **fig. 14**)

- a one-piece pressed steel cage, ball centred, no designation suffix (**a**)
- a two-piece pressed steel cage, ball centred, no designation suffix (**b**)
- a one-piece (**c**) or two-piece injection moulded snap-type cage of glass fibre reinforced polyamide 6,6, ball centred, designation suffix TN9
- a one-piece (**c**) or two-piece injection moulded snap-type cage of polyamide 6,6, ball centred, designation suffix TN
- a one-piece or two-piece (**d**) machined brass cage, ball centred, designation suffix M or no suffix (large size).

Contact SKF for availability of bearings with non-standard cages.

Note

Self-aligning ball bearings with polyamide 6,6 cages can be operated at temperatures up to +120 °C. The lubricants generally used for rolling bearings do not have a detrimental effect on cage properties, with the exception of a few synthetic oils and greases with a synthetic oil base, and lubricants containing a high proportion of EP additives when used at high temperatures.

For bearing arrangements, which are to be operated at continuously high temperatures or under arduous conditions, it is recommended to use bearings with a pressed steel or machined brass cage.

For detailed information about the temperature resistance and the applicability of cages, please refer to the section "Cage materials", starting on **page 140**.

Axial load carrying capacity

The ability of a self-aligning ball bearing mounted on an adapter sleeve on smooth shafts without an integral shoulder to carry axial loads, depends on the friction between the sleeve and shaft. The permissible axial load can be approximately determined from

$$F_{ap} = 0{,}003\ B\ d$$

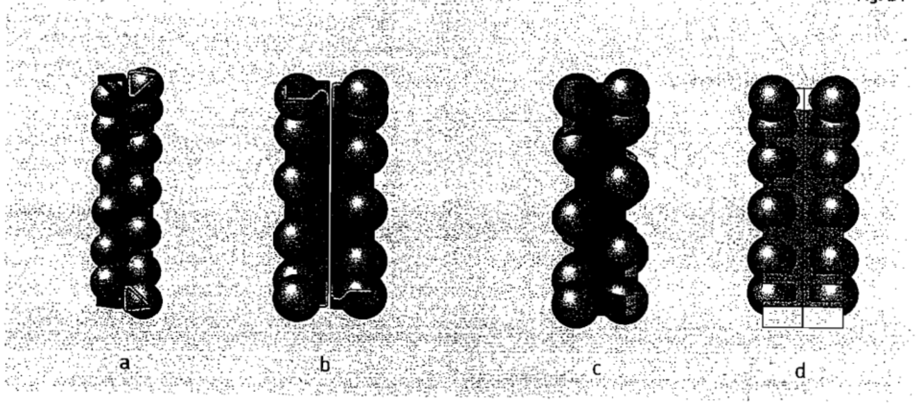
where

F_{ap} = maximum permissible axial load, kN

B = bearing width, mm

d = bearing bore diameter, mm

Fig. 14



Minimum load

In order to provide satisfactory operation, self-aligning ball bearings, like all ball and roller bearings, must always be subjected to a given minimum load, particularly if they are to operate at high speeds or are subjected to high accelerations or rapid changes in the direction of load. Under such conditions, the inertia forces of the balls and cage, and the friction in the lubricant, can have a detrimental influence on the rolling conditions in the bearing arrangement and may cause damaging sliding movements to occur between the balls and raceways.

The requisite minimum load to be applied to self-aligning ball bearings can be estimated using

$$P_m = 0{,}01\ C_0$$

where

P_m = equivalent minimum load, kN

C_0 = basic static load rating, kN (→ product tables)

When starting up at low temperatures or when the lubricant is highly viscous, even greater minimum loads may be required. The weight of the components supported by the bearing, together with external forces, generally exceeds the requisite minimum load. If this is not the case, the self-aligning ball bearing must be subjected to an additional radial load, for example, by increasing belt tension or by similar means.

Equivalent dynamic bearing load

$$P = F_r + Y_1 F_a \quad \text{when } F_a/F_r \le e$$
$$P = 0{,}65\ F_r + Y_2 F_a \quad \text{when } F_a/F_r > e$$

Values of Y_1, Y_2 and e can be found in the product tables.

Equivalent static bearing load

$$P_0 = F_r + Y_0 F_a$$

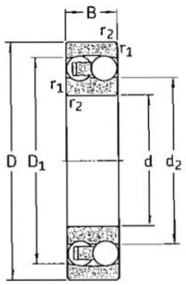
Values of Y_0 can be found in the product tables.

Supplementary designations

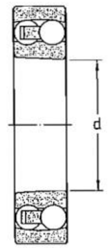
The designation suffixes used to identify certain features of SKF self-aligning ball bearings are explained in the following.

C3	Radial internal clearance greater than Normal
E	Optimized internal design
K	Tapered bore, taper 1:12
M	Machined brass cage, ball centred
2RS1	Sheet steel reinforced contact seal of acrylonitrile-butadiene rubber (NBR) on both sides of the bearing
TN	Injection moulded snap-type cage of polyamide 6,6, ball centred
TN9	Injection moulded snap-type cage of glass fibre reinforced polyamide 6,6, ball centred

Self-aligning ball bearings
d 5 – 25 mm

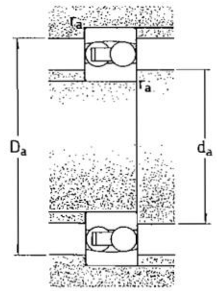


Cylindrical bore



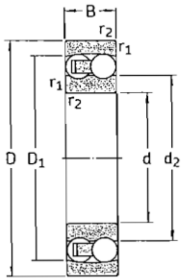
Tapered bore

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designations Bearing with cylindrical bore	tapered bore
d	D	B	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	
5	19	6	2,51	0,48	0,025	63 000	45 000	0,009	**135 TN9**	–
6	19	6	2,51	0,48	0,025	70 000	45 000	0,009	**126 TN9**	–
7	22	7	2,65	0,56	0,029	63 000	40 000	0,014	**127 TN9**	–
8	22	7	2,65	0,56	0,029	60 000	40 000	0,014	**108 TN9**	–
9	26	8	3,90	0,82	0,043	60 000	38 000	0,022	**129 TN9**	–
10	30	9	5,53	1,18	0,061	56 000	36 000	0,034	**1200 ETN9**	–
	30	14	8,06	1,73	0,090	50 000	34 000	0,047	**2200 ETN9**	–
12	32	10	6,24	1,43	0,072	50 000	32 000	0,040	**1201 ETN9**	–
	32	14	8,52	1,90	0,098	45 000	30 000	0,053	**2201 ETN9**	–
	37	12	9,36	2,16	0,12	40 000	28 000	0,067	**1301 ETN9**	–
	37	17	11,7	2,70	0,14	38 000	28 000	0,095	**2301**	–
15	35	11	7,41	1,76	0,09	45 000	28 000	0,049	**1202 ETN9**	–
	35	14	8,71	2,04	0,11	38 000	26 000	0,060	**2202 ETN9**	–
	42	13	10,8	2,60	0,14	34 000	24 000	0,094	**1302 ETN9**	–
	42	17	11,9	2,90	0,15	32 000	24 000	0,12	**2302**	–
17	40	12	8,84	2,20	0,12	38 000	24 000	0,073	**1203 ETN9**	–
	40	16	10,6	2,55	0,14	34 000	24 000	0,088	**2203 ETN9**	–
	47	14	12,7	3,40	0,18	28 000	20 000	0,12	**1303 ETN9**	–
	47	19	14,6	3,55	0,19	30 000	22 000	0,16	**2303**	–
20	47	14	12,7	3,4	0,18	32 000	20 000	0,12	**1204 ETN9**	1204 EKTN9
	47	18	16,8	4,15	0,22	28 000	20 000	0,14	**2204 ETN9**	–
	52	15	14,3	4	0,21	26 000	18 000	0,16	**1304 ETN9**	–
	52	21	18,2	4,75	0,24	26 000	19 000	0,22	**2304 TN**	–
25	52	15	14,3	4	0,21	28 000	18 000	0,14	**1205 ETN9**	1205 EKTN9
	52	18	16,8	4,4	0,23	26 000	18 000	0,16	**2205 ETN9**	2205 EKTN9
	62	17	19	5,4	0,28	22 000	15 000	0,26	**1305 ETN9**	1305 EKTN9
	62	24	27	7,1	0,37	22 000	16 000	0,34	**2305 ETN9**	–

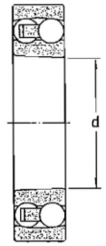


Dimensions				Abutment and fillet dimensions			Calculation factors			
d	d_2 ~	D_1 ~	$r_{1,2}$ min	d_a min	D_a max	r_a max	e	Y_1	Y_2	Y_0
mm				mm			–			
5	10,3	15,4	0,3	7,4	16,6	0,3	0,33	1,9	3	2
6	10,3	15,4	0,3	8,4	16,6	0,3	0,33	1,9	3	2
7	12,6	17,6	0,3	9,4	19,6	0,3	0,33	1,9	3	2
8	12,6	17,6	0,3	10,4	19,6	0,3	0,33	1,9	3	2
9	14,8	21,1	0,3	11,4	23,6	0,3	0,33	1,9	3	2
10	16,7	24,4	0,6	14,2	25,8	0,6	0,33	1,9	3	2
	15,3	24,3	0,6	14,2	25,8	0,6	0,54	1,15	1,8	1,3
12	18,2	26,4	0,6	16,2	27,8	0,6	0,33	1,9	3	2
	17,5	26,5	0,6	16,2	27,8	0,6	0,50	1,25	2	1,3
	20	30,8	1	17,6	31,4	1	0,35	1,8	2,8	1,8
	18,6	31	1	17,6	31,4	1	0,60	1,05	1,6	1,1
15	21,2	29,6	0,6	19,2	30,8	0,6	0,33	1,9	3	2
	20,9	30,2	0,6	19,2	30,8	0,6	0,43	1,5	2,3	1,6
	23,9	35,3	1	20,6	36,4	1	0,31	2	3,1	2,2
	23,2	35,2	1	20,6	36,4	1	0,52	1,2	1,9	1,3
17	24	33,6	0,6	21,2	35,8	0,6	0,31	2	3,1	2,2
	23,8	34,1	0,6	21,2	35,8	0,6	0,43	1,5	2,3	1,6
	28,9	41	1	22,6	41,4	1	0,30	2,1	3,3	2,2
	25,8	39,4	1	22,6	41,4	1	0,52	1,2	1,9	1,3
20	28,9	41	1	25,6	41,4	1	0,30	2,1	3,3	2,2
	27,4	41	1	25,6	41,4	1	0,40	1,6	2,4	1,6
	33,3	45,6	1,1	27	45	1	0,28	2,2	3,5	2,5
	28,8	43,7	1,1	27	45	1	0,52	1,2	1,9	1,3
25	33,3	45,6	1	30,6	46,4	1	0,28	2,2	3,5	2,5
	32,3	46,1	1	30,6	46,4	1	0,35	1,8	2,8	1,8
	37,8	52,5	1,1	32	55	1	0,28	2,2	3,5	2,5
	35,5	53,5	1,1	32	55	1	0,44	1,4	2,2	1,4

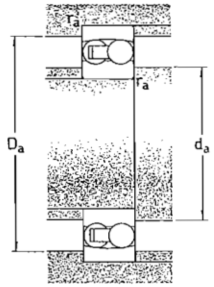
Self-aligning ball bearings
d **30 – 65** mm



Cylindrical bore



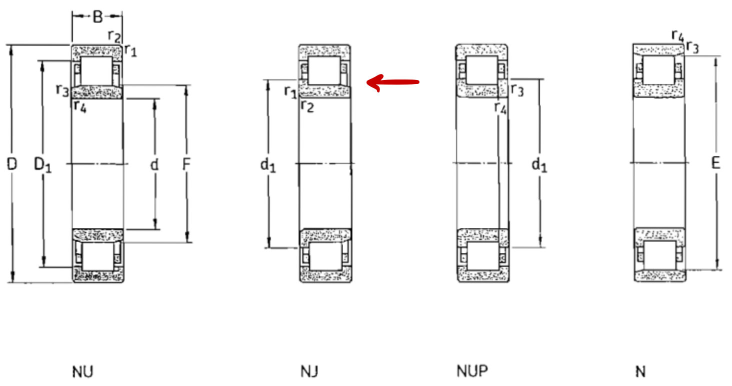
Tapered bore



Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designations Bearing with cylindrical bore	tapered bore
d	D	B	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	
30	62	16	15,6	4,65	0,24	24 000	15 000	0,22	**1206 ETN9**	**1206 EKTN9**
	62	20	23,8	6,7	0,35	22 000	15 000	0,26	**2206 ETN9**	**2206 EKTN9**
	72	19	22,5	6,8	0,36	19 000	13 000	0,39	**1306 ETN9**	**1306 EKTN9**
	72	27	31,2	8,8	0,45	18 000	13 000	0,50	**2306**	**2306 K**
35	72	17	19	6	0,31	20 000	13 000	0,32	**1207 ETN9**	**1207 EKTN9**
	72	23	30,7	8,8	0,46	18 000	12 000	0,40	**2207 ETN9**	**2207 EKTN9**
	80	21	26,5	8,5	0,43	16 000	11 000	0,51	**1307 ETN9**	**1307 EKTN9**
	80	31	39,7	11,2	0,59	16 000	12 000	0,68	**2307 ETN9**	**2307 EKTN9**
40	80	18	19,9	6,95	0,36	18 000	11 000	0,42	**1208 ETN9**	**1208 EKTN9**
	80	23	31,9	10	0,51	16 000	11 000	0,51	**2208 ETN9**	**2208 EKTN9**
	90	23	33,8	11,2	0,57	14 000	9 500	0,68	**1308 ETN9**	**1308 EKTN9**
	90	33	54	16	0,82	14 000	10 000	0,93	**2308 ETN9**	**2308 EKTN9**
45	85	19	22,9	7,8	0,40	17 000	11 000	0,47	**1209 ETN9**	**1209 EKTN9**
	85	23	32,5	10,6	0,54	15 000	10 000	0,55	**2209 ETN9**	**2209 EKTN9**
	100	25	39	13,4	0,70	12 000	8 500	0,96	**1309 ETN9**	**1309 EKTN9**
	100	36	63,7	19,3	1	13 000	9 000	1,25	**2309 ETN9**	**2309 EKTN9**
50	90	20	26,5	9,15	0,48	16 000	10 000	0,53	**1210 ETN9**	**1210 EKTN9**
	90	23	33,8	11,2	0,57	14 000	9 500	0,60	**2210 ETN9**	**2210 EKTN9**
	110	27	43,6	14	0,72	12 000	8 000	1,20	**1310 ETN9**	**1310 EKTN9**
	110	40	63,7	20	1,04	14 000	9 500	1,65	**2310**	**2310 K**
55	100	21	27,6	10,6	0,54	14 000	9 000	0,71	**1211 ETN9**	**1211 EKTN9**
	100	25	39	13,4	0,70	12 000	8 500	0,81	**2211 ETN9**	**2211 EKTN9**
	120	29	50,7	18	0,92	11 000	7 500	1,60	**1311 ETN9**	**1311 EKTN9**
	120	43	76,1	24	1,25	11 000	7 500	2,10	**2311**	**2311 K**
60	110	22	31,2	12,2	0,62	12 000	8 500	0,90	**1212 ETN9**	**1212 EKTN9**
	110	28	48,8	17	0,88	11 000	8 000	1,10	**2212 ETN9**	**2212 EKTN9**
	130	31	58,5	22	1,12	9 000	6 300	1,95	**1312 ETN9**	**1312 EKTN9**
	130	46	87,1	28,5	1,46	9 500	7 000	2,60	**2312**	**2312 K**
65	120	23	35,1	14	0,72	11 000	7 000	1,15	**1213 ETN9**	**1213 EKTN9**
	120	31	57,2	20	1,02	10 000	7 000	1,45	**2213 ETN9**	**2213 EKTN9**
	140	33	65	25,5	1,25	8 500	6 000	2,45	**1313 ETN9**	**1313 EKTN9**
	140	48	95,6	32,5	1,66	9 000	6 300	3,25	**2313**	**2313 K**

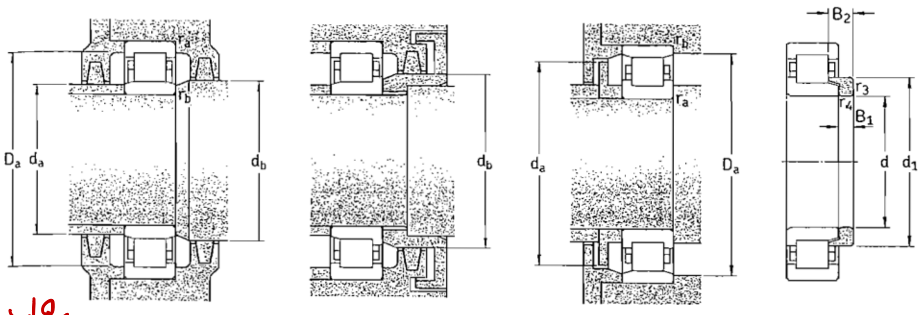
Dimensions				Abutment and fillet dimensions			Calculation factors			
d	d_2 ~	D_1 ~	$r_{1,2}$ min	d_a min	D_a max	r_a max	e	Y_1	Y_2	Y_0
mm				mm			–			
30	40,1	53	1	35,6	56,4	1	0,25	2,5	3,9	2,5
	38,8	55	1	35,6	56,4	1	0,33	1,9	3	2
	44,9	60,9	1,1	37	65	1	0,25	2,5	3,9	2,5
	41,7	60,9	1,1	37	65	1	0,44	1,4	2,2	1,4
35	47	62,3	1,1	42	65	1	0,23	2,7	4,2	2,8
	45,3	64,2	1,1	42	65	1	0,31	2	3,1	2,2
	51,5	69,5	1,5	44	71	1,5	0,25	2,5	3,9	2,5
	46,5	68,4	1,5	44	71	1,5	0,46	1,35	2,1	1,4
40	53,6	68,8	1,1	47	73	1	0,22	2,9	4,5	2,8
	52,4	71,6	1,1	47	73	1	0,28	2,2	3,5	2,5
	61,5	81,5	1,5	49	81	1,5	0,23	2,7	4,2	2,8
	53,7	79,2	1,5	49	81	1,5	0,40	1,6	2,4	1,6
45	57,5	73,7	1,1	52	78	1	0,21	3	4,6	3,2
	55,3	74,6	1,1	52	78	1	0,26	2,4	3,7	2,5
	67,7	89,5	1,5	54	91	1,5	0,23	2,7	4,2	2,8
	60,1	87,4	1,5	54	91	1,5	0,33	1,9	3	2
50	61,7	79,5	1,1	57	83	1	0,21	3	4,6	3,2
	61,5	81,5	1,1	57	83	1	0,23	2,7	4,2	2,8
	70,3	95	2	61	99	2	0,24	2,6	4,1	2,8
	65,8	94,4	2	61	99	2	0,43	1,5	2,3	1,6
55	70,1	88,4	1,5	64	91	1,5	0,19	3,3	5,1	3,6
	67,7	89,5	1,5	64	91	1,5	0,23	2,7	4,2	2,8
	77,7	104	2	66	109	2	0,23	2,7	4,2	2,8
	72	103	2	66	109	2	0,40	1,6	2,4	1,6
60	78	97,6	1,5	69	101	1,5	0,19	3,3	5,1	3,6
	74,5	98,6	1,5	69	101	1,5	0,24	2,6	4,1	2,8
	91,6	118	2,1	72	118	2	0,22	2,9	4,5	2,8
	76,9	112	2,1	72	118	2	0,33	1,9	3	2
65	85,3	106	1,5	74	111	1,5	0,18	3,5	5,4	3,6
	80,7	107	1,5	74	111	1,5	0,24	2,6	4,1	2,8
	99	127	2,1	77	128	2	0,22	2,9	4,5	2,8
	85,5	122	2,1	77	128	2	0,37	1,7	2,6	1,8

Single row cylindrical roller bearings
d **15 – 25** mm



F_r

$C = P(L)^{1/n} \rightarrow 10/3$



Angle ring

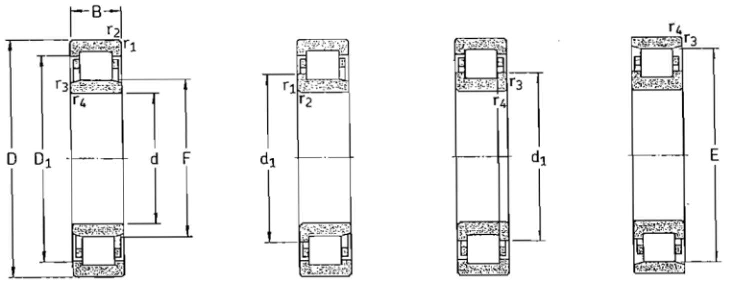
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass Bearing with standard cage	Designations Bearing with standard cage	Alternative standard cage designs[1]
d	D	B	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	
15	35	11	12,5	10,2	1,22	22 000	26 000	0,047	**NU 202 ECP**	–
	35	11	12,5	10,2	1,22	22 000	26 000	0,048	**NJ 202 ECP**	–
17	40	12	17,2	14,3	1,73	19 000	22 000	0,068	**NU 203 ECP**	ML
	40	12	17,2	14,3	1,73	19 000	22 000	0,070	**NJ 203 ECP**	ML
	40	12	17,2	14,3	1,73	19 000	22 000	0,073	**NUP 203 ECP**	ML
	40	12	17,2	14,3	1,73	19 000	22 000	0,066	**N 203 ECP**	–
	40	16	23,8	21,6	2,65	19 000	22 000	0,087	**NU 2203 ECP**	–
	40	16	23,8	21,6	2,65	19 000	22 000	0,093	**NJ 2203 ECP**	–
	40	16	23,8	21,6	2,65	19 000	22 000	0,097	**NUP 2203 ECP**	–
	47	14	24,6	20,4	2,55	15 000	20 000	0,12	**NU 303 ECP**	–
	47	14	24,6	20,4	2,55	15 000	20 000	0,12	**NJ 303 ECP**	–
	47	14	24,6	20,4	2,55	15 000	20 000	0,12	**N 303 ECP**	–
20	47	14	25,1	22	2,75	16 000	19 000	0,11	**NU 204 ECP**	ML
	47	14	25,1	22	2,75	16 000	19 000	0,11	**NJ 204 ECP**	ML
	47	14	25,1	22	2,75	16 000	19 000	0,12	**NUP 204 ECP**	ML
	47	14	25,1	22	2,75	16 000	19 000	0,11	**N 204 ECP**	–
	47	18	29,7	27,5	3,45	16 000	19 000	0,14	**NU 2204 ECP**	–
	47	18	29,7	27,5	3,45	16 000	19 000	0,14	**NJ 2204 ECP**	–
	52	15	35,5	26	3,25	15 000	18 000	0,15	★ **NU 304 ECP**	–
	52	15	35,5	26	3,25	15 000	18 000	0,15	★ **NJ 304 ECP**	–
	52	15	35,5	26	3,25	15 000	18 000	0,16	★ **NUP 304 ECP**	–
	52	15	35,5	26	3,25	15 000	18 000	0,15	★ **N 304 ECP**	–
	52	21	47,5	38	4,8	14 000	18 000	0,21	★ **NU 2304 ECP**	–
	52	21	47,5	38	4,8	14 000	18 000	0,22	★ **NJ 2304 ECP**	–
	52	21	47,5	38	4,8	14 000	18 000	0,23	★ **NUP 2304 ECP**	–
25	47	12	14,2	13,2	1,4	18 000	18 000	0,083	**NU 1005**	–
	52	15	28,6	27	3,35	14 000	16 000	0,13	**NU 205 ECP**	J, ML
	52	15	28,6	27	3,35	14 000	16 000	0,14	**NJ 205 ECP**	J, ML
	52	15	28,6	27	3,35	14 000	16 000	0,14	**NUP 205 ECP**	ML
	52	15	28,6	27	3,35	14 000	16 000	0,13	**N 205 ECP**	–

★ SKF Explorer bearing
[1] When ordering bearings with an alternative standard cage the suffix of the standard cage has to be replaced by the suffix of the cage in question, e.g. NU 203 ECP becomes NU 203 ECML (for speed ratings → **page 517**)

Dimensions							Abutment and fillet dimensions						Calculation factor	Angle ring Designation	Mass	Dimensions	
d	d_1 ~	D_1 ~	F, E	$r_{1,2}$ min	$r_{3,4}$ min	s[1]	d_a min	d_a max	d_b, D_a min	D_a max	r_a max	r_b max	k_r			B_1	B_2
mm							mm						–	–	kg	mm	
15	–	27,9	19,3	0,6	0,3	1	17,4	18,5	21	30,8	0,6	0,3	0,15	–			
	21,9	27,9	19,3	0,6	0,3	1	18,5	18,5	23	30,8	0,6	0,3	0,15	–			
17	–	32,4	22,1	0,6	0,3	1	19,4	21	24	35,8	0,6	0,3	0,15	–			
	25	32,4	22,1	0,6	0,3	1	21	21	27	35,8	0,6	0,3	0,15	–			
	25	32,4	22,1	0,6	0,3	–	21,2	–	27	35,8	0,6	0,3	0,15	–			
	25	–	35,1	0,6	0,3	1	21,2	33	37	37,6	0,6	0,3	0,15	–			
	–	32,4	22,1	0,6	0,3	1,5	19,4	21	24	35,8	0,6	0,3	0,20	–			
	25	32,4	22,1	0,6	0,3	1,5	21	21	27	35,8	0,6	0,3	0,20	–			
	25	32,4	22,1	0,6	0,3	–	21,2	–	27	35,8	0,6	0,3	0,20	–			
	–	37	24,2	1	0,6	1	21,2	23	26	41,4	1	0,6	0,15	–			
	27,7	37	24,2	1	0,6	1	22,6	23	29	41,4	1	0,6	0,15	–			
	27,7	–	40,2	1	0,6	1	22,6	38	42	42,8	1	0,6	0,15	–			
20	–	38,8	26,5	1	0,6	1	24,2	25	28	41,4	1	0,6	0,15	–			
	29,7	38,8	26,5	1	0,6	1	25	25	31	41,4	1	0,6	0,15	–			
	29,7	38,8	26,5	1	0,6	–	25,6	–	31	41,4	1	0,6	0,15	–			
	29,7	–	41,5	1	0,6	1	25,6	40	43	42,8	1	0,6	0,15	–			
	–	38,8	26,5	1	0,6	2	24,2	25	28	41,4	1	0,6	0,20	–			
	29,7	38,8	26,5	1	0,6	2	25	25	31	41,4	1	0,6	0,20	–			
	31,2	42,4	27,5	1,1	0,6	0,9	24,2	26	29	45	1	0,6	0,15	**HJ 304 EC**	0,017	4	6,5
	31,2	42,4	27,5	1,1	0,6	0,9	27	29	33	45	1	0,6	0,15	**HJ 304 EC**	0,017	4	6,5
	31,2	42,4	27,5	1,1	0,6	–	27	–	33	45	1	0,6	0,15	–			
	31,2	–	45,5	1,1	0,6	0,9	27	44	47	47,8	1	0,6	0,15	–			
	–	42,4	27,5	1,1	0,6	1,9	24,2	26	29	45	1	0,6	0,29	–			
	31,2	42,4	27,5	1,1	0,6	1,9	26	26	33	45	1	0,6	0,29	–			
	31,2	42,4	27,5	1,1	0,6	–	27	–	33	45	1	0,6	0,29	–			
25	–	38,8	30,5	0,6	0,3	2	27	29	32	43,8	0,6	0,3	0,1	–			
	34,7	43,8	31,5	1	0,6	1,3	29,2	30	33	46,4	1	0,6	0,15	**HJ 205 EC**	0,014	3	6
	34,7	43,8	31,5	1	0,6	1,3	30	30	36	46,4	1	0,6	0,15	**HJ 205 EC**	0,014	3	6
	34,7	43,8	31,5	1	0,6	–	30,6	–	36	46,4	1	0,6	0,15	–			
	34,7	–	46,5	1	0,6	1,3	30,6	45	48	47,8	1	0,6	0,15	–			

[1] Permissible axial displacement from the normal position of one bearing ring in relation to the other

Single row cylindrical roller bearings
d **25 – 30** mm

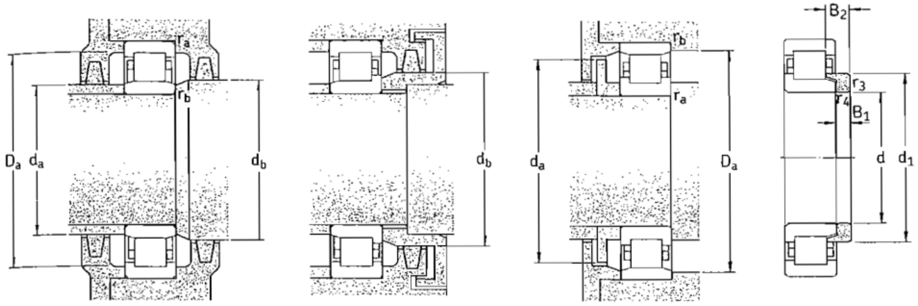


NU NJ NUP N

Principal dimensions d	D	B	Basic load ratings dynamic C	static C_0	Fatigue load limit P_u	Speed ratings Reference speed	Limiting speed	Mass Bearing with standard cage	Designations Bearing with standard cage	Alternative standard cage designs[1]
mm			kN		kN	r/min		kg	–	
25	52	18	34,1	34	4,25	14 000	16 000	0,16	**NU 2205 ECP**	**ML**
cont.	52	18	34,1	34	4,25	14 000	16 000	0,17	**NJ 2205 ECP**	**ML**
	52	18	34,1	34	4,25	14 000	16 000	0,17	**NUP 2205 ECP**	**ML**
	62	17	46,5	36,5	4,55	12 000	15 000	0,24	**★ NU 305 ECP**	**J, ML**
	62	17	46,5	36,5	4,55	12 000	15 000	0,24	**★ NJ 305 ECP**	**J, ML**
	62	17	46,5	36,5	4,55	12 000	15 000	0,25	**★ NUP 305 ECP**	**J, ML**
	62	17	46,5	36,5	4,55	12 000	15 000	0,24	**★ N 305 ECP**	–
	62	24	64	55	6,95	12 000	15 000	0,34	**★ NU 2305 ECP**	**J, ML**
	62	24	64	55	6,95	12 000	15 000	0,35	**★ NJ 2305 ECP**	**ML**
	62	24	64	55	6,95	12 000	15 000	0,36	**★ NUP 2305 ECP**	**ML**
30	55	13	17,9	17,3	1,86	14 000	15 000	0,12	**NU 1006**	–
	62	16	44	36,5	4,55	13 000	14 000	0,20	**★ NU 206 ECP**	**J, ML**
	62	16	44	36,5	4,55	13 000	14 000	0,20	**★ NJ 206 ECP**	**J, ML**
	62	16	44	36,5	4,55	13 000	14 000	0,21	**★ NUP 206 ECP**	**ML**
	62	16	44	36,5	4,55	13 000	14 000	0,20	**★ N 206 ECP**	–
	62	20	55	49	6,1	13 000	14 000	0,26	**★ NU 2206 ECP**	**J, ML**
	62	20	55	49	6,1	13 000	14 000	0,26	**★ NJ 2206 ECP**	**J, ML**
	62	20	55	49	6,1	13 000	14 000	0,27	**★ NUP 2206 ECP**	**ML**
	72	19	58,5	48	6,2	11 000	12 000	0,36	**★ NU 306 ECP**	**J, M, ML**
	72	19	58,5	48	6,2	11 000	12 000	0,36	**★ NJ 306 ECP**	**J, M, ML**
	72	19	58,5	48	6,2	11 000	12 000	0,38	**★ NUP 306 ECP**	**J, M, ML**
	72	19	58,5	48	6,2	11 000	12 000	0,36	**★ N 306 ECP**	–
	72	27	83	75	9,65	11 000	12 000	0,53	**★ NU 2306 ECP**	**ML**
	72	27	83	75	9,65	11 000	12 000	0,54	**★ NJ 2306 ECP**	**ML**
	72	27	83	75	9,65	11 000	12 000	0,55	**★ NUP 2306 ECP**	**ML**
	90	23	60,5	53	6,8	9 000	11 000	0,75	**NU 406**	–
	90	23	60,5	53	6,8	9 000	11 000	0,79	**NJ 406**	–

★ SKF Explorer bearing

[1] When ordering bearings with an alternative standard cage the suffix of the standard cage has to be replaced by the suffix of the cage in question, e.g. NU 2205 ECP becomes NU 2205 ECML (for speed ratings → **page 517**)

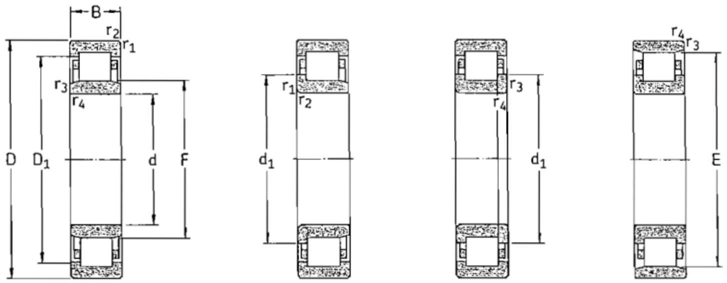


Angle ring

Dimensions d	d_1 ~	D_1 ~	F, E	$r_{1,2}$ min	$r_{3,4}$ min	s[1]	Abutment and fillet dimensions d_a min	d_a max	d_b, D_a min	D_a max	r_a max	r_b max	Calculation factor k_r	Angle ring Designation	Mass	Dimensions B_1	B_2
mm							mm						–	–	kg	mm	
25	34,7	43,8	31,5	1	0,6	1,8	29,2	30	33	46,4	1	0,6	0,20	**HJ 2205 EC**	0,014	3	6,5
cont.	34,7	43,8	31,5	1	0,6	1,8	30	30	36	46,4	1	0,6	0,20	**HJ 2205 EC**	0,014	3	6,5
	34,7	43,8	31,5	1	0,6	–	30,6	–	36	46,4	1	0,6	0,20	–			
	38,1	50,7	34	1,1	1,1	1,3	32	32	36	55	1	1	0,15	**HJ 305 EC**	0,023	4	7
	38,1	50,7	34	1,1	1,1	1,3	32	32	40	55	1	1	0,15	**HJ 305 EC**	0,023	4	7
	38,1	50,7	34	1,1	1,1	–	32	–	40	55	1	1	0,15	–			
	38,1	–	54	1,1	1,1	1,3	32	52	56	55	1	1	0,15	–			
	38,1	50,7	34	1,1	1,1	2,3	32	32	36	55	1	1	0,25	**HJ 2305 EC**	0,025	4	8
	38,1	50,7	34	1,1	1,1	2,3	32	32	40	55	1	1	0,25	**HJ 2305 EC**	0,025	4	8
	38,1	50,7	34	1,1	1,1	–	32	–	40	55	1	1	0,25	–			
30	–	45,6	36,5	1	0,6	2,1	33,2	35	38	50,4	1	0,6	0,1	–			
	41,2	52,5	37,5	1	0,6	1,3	34,2	36	39	56,4	1	0,6	0,15	**HJ 206 EC**	0,025	4	7
	41,2	52,5	37,5	1	0,6	1,3	35,6	36	43	56,4	1	0,6	0,15	**HJ 206 EC**	0,025	4	7
	41,2	52,5	37,5	1	0,6	–	35,6	–	43	56,4	1	0,6	0,15	–			
	41,2	–	55,5	1	0,6	1,3	35,6	54	57	57,8	1	0,6	0,15	–			
	–	52,5	37,5	1	0,6	1,8	34	36	39	57	1	0,6	0,2	–			
	41,2	52,5	37,5	1	0,6	1,8	34	36	43	57	1	0,6	0,2	–			
	41,2	52,5	37,5	1	0,6	–	34	–	43	57	1	0,6	0,2	–			
	45	58,9	40,5	1,1	1,1	1,4	37	39	42	65	1	1	0,15	**HJ 306 EC**	0,042	5	8,5
	45	58,9	40,5	1,1	1,1	1,4	37	39	47	65	1	1	0,15	**HJ 306 EC**	0,042	5	8,5
	45	58,9	40,5	1,1	1,1	–	37	–	47	65	1	1	0,15	–			
	45	–	62,5	1,1	1,1	1,4	37	60	64	65	1	1	0,15	–			
	–	58,9	40,5	1,1	1,1	2,4	37	39	42	65	1	1	0,25	–			
	45	58,9	40,5	1,1	1,1	2,4	37	39	47	65	1	1	0,25	–			
	45	58,9	40,5	1,1	1,1	–	37	–	47	65	1	1	0,25	–			
	50,5	66,6	45	1,5	1,5	1,6	41	43	47	79	1,5	1,5	0,15	**HJ 406**	0,080	7	11,5
	50,5	66,6	45	1,5	1,5	1,6	41	43	47	79	1,5	1,5	0,15	**HJ 406**	0,080	7	11,5

[1] Permissible axial displacement from the normal position of one bearing ring in relation to the other

Single row cylindrical roller bearings
d 35 – 40 mm

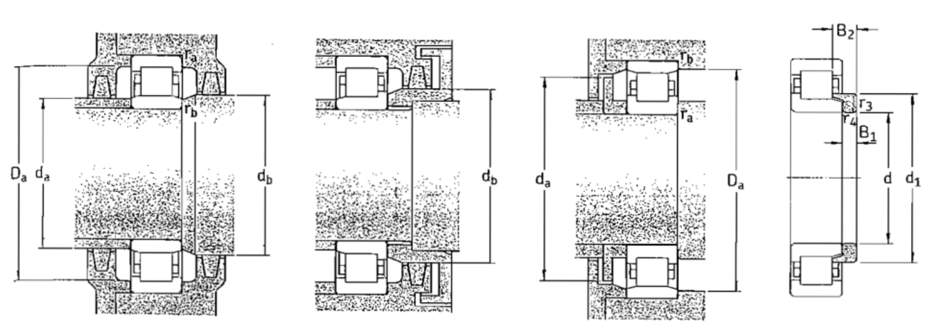


NU NJ NUP N

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass Bearing with standard cage	Designations Bearing with standard cage	Alternative standard cage designs[1]
d	D	B	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	
35	62	14	35,8	38	4,55	12 000	13 000	0,16	NU 1007 ECP	–
	72	17	56	48	6,1	11 000	12 000	0,29	* NU 207 ECP	J, M, ML
	72	17	56	48	6,1	11 000	12 000	0,30	* NJ 207 ECP	J, M, ML
	72	17	56	48	6,1	11 000	12 000	0,31	* NUP 207 ECP	J, M, ML
	72	17	56	48	6,1	11 000	12 000	0,30	* N 207 ECP	–
	72	23	69,5	63	8,15	11 000	12 000	0,40	* NU 2207 ECP	J, ML
	72	23	69,5	63	8,15	11 000	12 000	0,41	* NJ 2207 ECP	J, ML
	72	23	69,5	63	8,15	11 000	12 000	0,42	* NUP 2207 ECP	ML
	80	21	75	63	8,15	9 500	11 000	0,47	* NU 307 ECP	J, M, ML
	80	21	75	63	8,15	9 500	11 000	0,49	* NJ 307 ECP	J, M, ML
	80	21	75	63	8,15	9 500	11 000	0,50	* NUP 307 ECP	J, M, ML
	80	21	75	63	8,15	9 500	11 000	0,48	* N 307 ECP	–
	80	31	106	98	12,7	9 500	11 000	0,72	* NU 2307 ECP	J
	80	31	106	98	12,7	9 500	11 000	0,73	* NJ 2307 ECP	–
	80	31	106	98	12,7	9 500	11 000	0,76	* NUP 2307 ECP	–
	100	25	76,5	69,5	9	8 000	9 500	1,00	NU 407	–
	100	25	76,5	69,5	9	8 000	9 500	1,05	NJ 407	–
40	68	15	25,1	26	3	11 000	18 000	0,23	NU 1008 ML	–
	80	18	62	53	6,7	9 500	11 000	0,37	* NU 208 ECP	J, M, ML
	80	18	62	53	6,7	9 500	11 000	0,39	* NJ 208 ECP	J, M, ML
	80	18	62	53	6,7	9 500	11 000	0,40	* NUP 208 ECP	J, M, ML
	80	18	62	53	6,7	9 500	11 000	0,37	* N 208 ECP	–
	80	23	81,5	75	9,65	9 500	11 000	0,49	* NU 2208 ECP	J, ML
	80	23	81,5	75	9,65	9 500	11 000	0,50	* NJ 2208 ECP	J, ML
	80	23	81,5	75	9,65	9 500	11 000	0,51	* NUP 2208 ECP	J, ML
	90	23	93	78	10,2	8 000	9 500	0,65	* NU 308 ECP	J, M, ML
	90	23	93	78	10,2	8 000	9 500	0,67	* NJ 308 ECP	J, M, ML
	90	23	93	78	10,2	8 000	9 500	0,68	* NUP 308 ECP	M, ML
	90	23	93	78	10,2	8 000	9 500	0,65	* N 308 ECP	–

* SKF Explorer bearing
[1] When ordering bearings with an alternative standard cage the suffix of the standard cage has to be replaced by the suffix of the cage in question, e.g. NU 207 ECP becomes NU 207 ECML (for speed ratings → page 517)

SKF

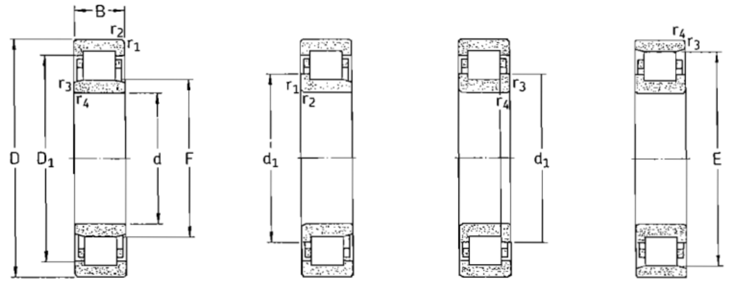


Angle ring

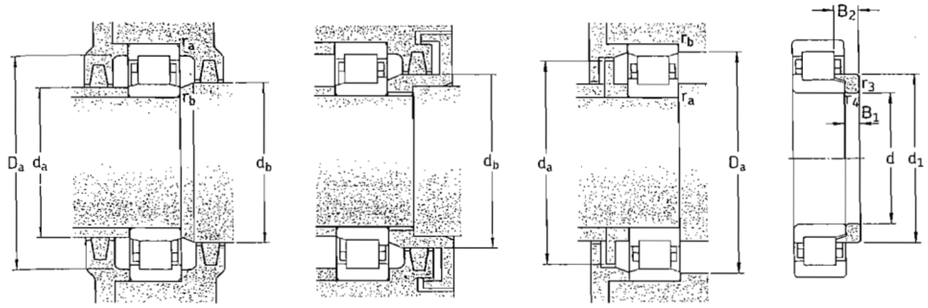
Dimensions d	d_1 ~	D_1 ~	F, E	$r_{1,2}$ min	$r_{3,4}$ min	s[1]	Abutment and fillet dimensions d_a min	d_a max	d_b, D_a min	D_a max	r_a max	r_b max	Calculation factor k_r	Angle ring Designation	Mass	Dimensions B_1	B_2
mm							mm						–	–	kg	mm	
35	–	54,5	42	1	0,6	1	38,2	41	44	56	1	0,6	0,1	–			
	48,1	60,7	44	1,1	0,6	1,3	39,2	42	46	65	1	0,6	0,15	HJ 207 EC	0,033	4	7
	48,1	60,7	44	1,1	0,6	1,3	42	42	50	65	1	0,6	0,15	HJ 207 EC	0,033	4	7
	48,1	60,7	44	1,1	0,6	–	42	–	50	65	1	0,6	0,15	–			
	48,1	–	64	1,1	0,6	1,3	42	62	66	67,8	1	0,6	0,15	–			
	–	60,7	44	1,1	0,6	2,8	39,2	42	46	65	1	0,6	0,2	–			
	48,1	60,7	44	1,1	0,6	2,8	42	42	50	65	1	0,6	0,2	–			
	48,1	60,7	44	1,1	0,6	–	42	–	48	65	1	0,6	0,2	–			
	51	66,3	46,2	1,5	1,1	1,2	42	44	48	71	1,5	1	0,15	HJ 307 EC	0,058	6	9,5
	51	66,3	46,2	1,5	1,1	1,2	44	44	53	71	1,5	1	0,15	HJ 307 EC	0,058	6	9,5
	51	66,3	46,2	1,5	1,1	–	44	–	53	71	1,5	1	0,15	–			
	51	–	70,2	1,5	1,1	1,2	44	68	72	73	1,5	1	0,15	–			
	–	66,3	46,2	1,5	1,1	2,7	42	44	48	71	1,5	1	0,25	–			
	51	66,3	46,2	1,5	1,1	2,7	44	44	53	71	1,5	1	0,25	–			
	51	66,3	46,2	1,5	1,1	–	44	–	53	71	1,5	1	0,25	–			
	–	76,1	53	1,5	1,5	1,7	46	50	55	89	1,5	1,5	0,15	–			
	59	76,1	53	1,5	1,5	1,7	46	50	61	89	1,5	1,5	0,15	–			
40	–	57,6	47	1	0,6	2,4	43,2	45	49	63,4	1	0,6	0,1	–			
	54	67,9	49,5	1,1	1,1	1,4	47	48	51	73	1	1	0,15	HJ 208 EC	0,047	5	8,5
	54	67,9	49,5	1,1	1,1	1,4	47	48	56	73	1	1	0,15	HJ 208 EC	0,047	5	8,5
	54	67,9	49,5	1,1	1,1	–	47	–	56	73	1	1	0,15	–			
	54	–	71,5	1,1	1,1	1,4	47	69	73	73	1	1	0,15	–			
	54	67,9	49,5	1,1	1,1	1,9	47	48	51	73	1	1	0,2	HJ 2208 EC	0,048	5	9
	54	67,9	49,5	1,1	1,1	1,9	47	48	56	73	1	1	0,2	HJ 2208 EC	0,048	5	9
	54	67,9	49,5	1,1	1,1	–	47	–	56	73	1	1	0,2	–			
	57,5	75,6	52	1,5	1,5	1,4	49	50	54	81	1,5	1,5	0,15	HJ 308 EC	0,084	7	11
	57,5	75,6	52	1,5	1,5	1,4	49	50	60	81	1,5	1,5	0,15	HJ 308 EC	0,084	7	11
	57,5	75,6	52	1,5	1,5	–	49	–	60	81	1,5	1,5	0,15	–			
	57,5	–	80	1,5	1,5	1,4	49	78	82	81	1,5	1,5	0,15	–			

[1] Permissible axial displacement from the normal position of one bearing ring in relation to the other

Single row cylindrical roller bearings
d 40 – 50 mm



NU NJ NUP N



Angle ring

Principal dimensions d	D	B	Basic load ratings dynamic C	static C_0	Fatigue load limit P_u	Speed ratings Reference speed	Limiting speed	Mass Bearing with standard cage	Designations Bearing with standard cage	Alternative standard cage designs[1]
mm			kN		kN	r/min		kg	–	
40 cont.	90	33	129	120	15,3	8 000	9 500	0,94	* NU 2308 ECP	J, M, ML
	90	33	129	120	15,3	8 000	9 500	0,95	* NJ 2308 ECP	J, M, ML
	90	33	129	120	15,3	8 000	9 500	0,98	* NUP 2308 ECP	M, ML
	110	27	96,8	90	11,6	7 000	8 500	1,25	NU 408	–
	110	27	96,8	90	11,6	7 000	8 500	1,30	NJ 408	–
45	75	16	44,6	52	6,3	9 500	11 000	0,26	NU 1009 ECP	–
	85	19	69,5	64	8,15	9 000	9 500	0,43	* NU 209 ECP	J, M, ML
	85	19	69,5	64	8,15	9 000	9 500	0,44	* NJ 209 ECP	J, M, ML
	85	19	69,5	64	8,15	9 000	9 500	0,45	* NUP 209 ECP	J, M, ML
	85	19	69,5	64	8,15	9 000	9 500	0,43	* N 209 ECP	–
	85	23	85	81,5	10,6	9 000	9 500	0,52	* NU 2209 ECP	J
	85	23	85	81,5	10,6	9 000	9 500	0,54	* NJ 2209 ECP	J
	85	23	85	81,5	10,6	9 000	9 500	0,55	* NUP 2209 ECP	–
	100	25	112	100	12,9	7 500	8 500	0,90	* NU 309 ECP	J, M, ML
	100	25	112	100	12,9	7 500	8 500	0,92	* NJ 309 ECP	J, M, ML
	100	25	112	100	12,9	7 500	8 500	0,95	* NUP 309 ECP	J, ML
	100	25	112	100	12,9	7 500	8 500	0,88	* N 309 ECP	–
	100	36	160	153	20	7 500	8 500	1,30	* NU 2309 ECP	ML
	100	36	160	153	20	7 500	8 500	1,33	* NJ 2309 ECP	ML
	100	36	160	153	20	7 500	8 500	1,36	* NUP 2309 ECP	ML
	120	29	106	102	13,4	6 700	7 500	1,64	NU 409	–
	120	29	106	102	13,4	6 700	7 500	1,67	NJ 409	–
50	80	16	46,8	56	6,7	9 000	9 500	0,27	NU 1010 ECP	–
	90	20	73,5	69,5	8,8	8 500	9 000	0,48	* NU 210 ECP	J, M, ML
	90	20	73,5	69,5	8,8	8 500	9 000	0,49	* NJ 210 ECP	J, M, ML
	90	20	73,5	69,5	8,8	8 500	9 000	0,51	* NUP 210 ECP	J, ML
	90	20	73,5	69,5	8,8	8 500	9 000	0,48	* N 210 ECP	–

* SKF Explorer bearing

[1] When ordering bearings with an alternative standard cage the suffix of the standard cage has to be replaced by the suffix of the cage in question, e.g. NU 2308 ECP becomes NU 2308 ECML (for speed ratings → **page 517**)

Dimensions d	d_1 ~	D_1 ~	F, E	$r_{1,2}$ min	$r_{3,4}$ min	s[1]	Abutment and fillet dimensions d_a min	d_a max	d_b, D_a min	D_a max	r_a max	r_b max	Calculation factor k_r	Angle ring Designation	Mass	Dimensions B_1	B_2
mm							mm						–	–	kg	mm	
40 cont.	–	75,6	52	1,5	1,5	2,9	49	50	54	81	1,5	1,5	0,25	–			
	57,5	75,6	52	1,5	1,5	2,9	49	50	60	81	1,5	1,5	0,25	–			
	57,5	75,6	52	1,5	1,5	–	49	–	60	81	1,5	1,5	0,25	–			
	–	84,2	58	2	2	2,5	53	56	60	97	2	2	0,15	–			
	64,8	84,2	58	2	2	2,5	53	56	67	97	2	2	0,15	–			
45	–	65,3	52,5	1	0,6	0,9	48,2	51	54	70,4	1	0,6	0,1	–			
	59	73	54,5	1,1	1,1	1,2	52	53	56	78	1	1	0,15	HJ 209 EC	0,052	5	8,5
	59	73	54,5	1,1	1,1	1,2	52	53	61	78	1	1	0,15	HJ 209 EC	0,052	5	8,5
	59	73	54,5	1,1	1,1	–	52	–	61	78	1	1	0,15	–			
	59	–	76,5	1,1	1,1	1,2	52	74	78	78	1	1	0,15	–			
	–	73	54,5	1,1	1,1	1,7	52	53	56	78	1	1	0,2	–			
	59	73	54,5	1,1	1,1	1,7	52	53	56	78	1	1	0,2				
	59	73	54,5	1,1	1,1	–	52	–	61	78	1	1	0,2	–			
	64,4	83,8	58,5	1,5	1,5	1,7	54	56	61	91	1,5	1,5	0,15	HJ 309 EC	0,11	7	11,5
	64,4	83,8	58,5	1,5	1,5	1,7	54	56	67	91	1,5	1,5	0,15	HJ 309 EC	0,11	7	11,5
	64,4	83,8	58,5	1,5	1,5	–	54	–	67	91	1,5	1,5	0,15	–			
	64,4	–	88,5	1,5	1,5	1,7	54	86	91	91	1,5	1,5	0,15	–			
	–	83,8	58,5	1,5	1,5	3,2	54	56	61	91	1,5	1,5	0,25	–			
	64,4	83,8	58,5	1,5	1,5	3,2	54	56	67	91	1,5	1,5	0,25	–			
	64,4	83,8	58,5	1,5	1,5	–	54	–	67	91	1,5	1,5	0,25	–			
	71,8	92,2	64,5	2	2	2,5	58	62	67	107	2	2	0,15	HJ 409	0,18	8	13,5
	71,8	92,2	64,5	2	2	2,5	58	62	74	107	2	2	0,15	HJ 409	0,18	8	13,5
50	–	70	57,5	1	0,6	1	53,2	56	60	75,4	1	0,6	0,1	–			
	64	78	59,5	1,1	1,1	1,5	57	57	62	83	1	1	0,15	HJ 210 EC	0,058	5	9
	64	78	59,5	1,1	1,1	1,5	57	57	66	83	1	1	0,15	HJ 210 EC	0,058	5	9
	64	78	59,5	1,1	1,1	–	57	–	66	83	1	1	0,15	–			
	64	–	81,5	1,1	1,1	1,5	57	79	83	83	1	1	0,15	–			

[1] Permissible axial displacement from the normal position of one bearing ring in relation to the other

Equivalent dynamic bearing load

$P = F_r$ when $F_a/F_r \le e$
$P = 0{,}4\,F_r + Y F_a$ when $F_a/F_r > e$

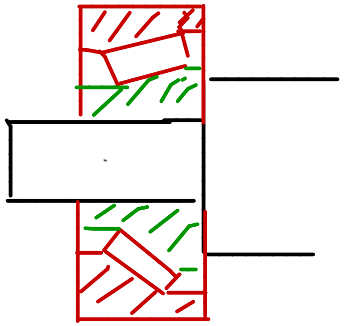
The values of the calculation factors e and Y can be found in the product tables.

Equivalent static bearing load

$P_0 = 0{,}5\,F_r + Y_0 F_a$

$n = \frac{C_0}{P_0}$

When $P_0 < F_r$, $P_0 = F_r$ should be used. The value of the calculation factor Y_0 can be found in the product tables.



Determining axial force for bearings mounted singly or paired in tandem

When a radial load is applied to a single row tapered roller bearing, the load is transmitted from one raceway to the other at an angle to the bearing axis and an internal axial force will be induced in the bearing. This must be considered when calculating the equivalent bearing loads for bearing arrangements consisting of two single bearings and/or bearing pairs arranged in tandem.

The necessary equations are provided in **table 3** for the various bearing arrangements and load cases. The equations are only valid if the bearings are adjusted against each other to practically zero clearance, but without any preload. In the arrangements shown, bearing A is subjected to a radial load F_{rA} and bearing B to radial load F_{rB}. Values of the loads F_{rA} and F_{rB} are always considered positive even when they act in the direction opposite to that shown in the figures. The radial loads act at the pressure centres of the bearings (dimension a in the product tables).

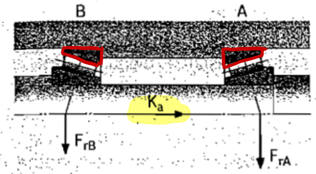
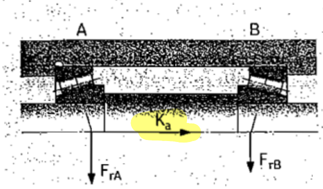
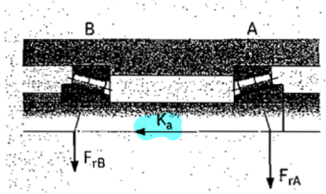
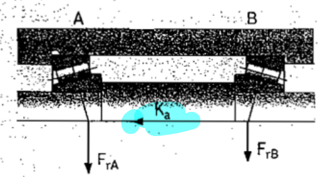
In addition an external force K_a acts on the shaft (or on the housing). Cases 1c and 2c are also valid when $K_a = 0$. Values of the factor Y can be found in the product tables.

SKF

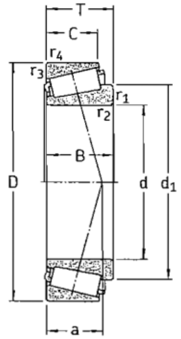
SKF

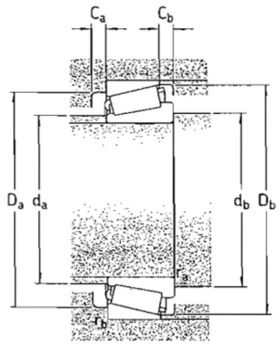
Table 3

Axial loading of bearing arrangements incorporating two single row tapered roller bearings and/or bearing pairs in tandem

Arrangement	Load case	Axial forces	
Back-to-back 	1a) $\frac{F_{rA}}{Y_A} \ge \frac{F_{rB}}{Y_B}$ $K_a \ge 0$	$F_{aA} = \frac{0{,}5\,F_{rA}}{Y_A}$	$F_{aB} = F_{aA} + K_a$
Face-to-face 	1b) $\frac{F_{rA}}{Y_A} < \frac{F_{rB}}{Y_B}$ $K_a \ge 0{,}5\left(\frac{F_{rB}}{Y_B} - \frac{F_{rA}}{Y_A}\right)$	$F_{aA} = \frac{0{,}5\,F_{rA}}{Y_A}$	$F_{aB} = F_{aA} + K_a$
	1c) $\frac{F_{rA}}{Y_A} < \frac{F_{rB}}{Y_B}$ $K_a < 0{,}5\left(\frac{F_{rB}}{Y_B} - \frac{F_{rA}}{Y_A}\right)$	$F_{aA} = F_{aB} - K_a$	$F_{aB} = \frac{0{,}5\,F_{rB}}{Y_B}$
Back-to-back 	2a) $\frac{F_{rA}}{Y_A} \le \frac{F_{rB}}{Y_B}$ $K_a \ge 0$	$F_{aA} = F_{aB} + K_a$	$F_{aB} = \frac{0{,}5\,F_{rB}}{Y_B}$
Face-to-face 	2b) $\frac{F_{rA}}{Y_A} > \frac{F_{rB}}{Y_B}$ $K_a \ge 0{,}5\left(\frac{F_{rA}}{Y_A} - \frac{F_{rB}}{Y_B}\right)$	$F_{aA} = F_{aB} + K_a$	$F_{aB} = \frac{0{,}5\,F_{rB}}{Y_B}$
	2c) $\frac{F_{rA}}{Y_A} > \frac{F_{rB}}{Y_B}$ $K_a < 0{,}5\left(\frac{F_{rA}}{Y_A} - \frac{F_{rB}}{Y_B}\right)$	$F_{aA} = \frac{0{,}5\,F_{rA}}{Y_A}$	$F_{aB} = F_{aA} - K_a$

Metric single row tapered roller bearings
d **15 – 32** mm

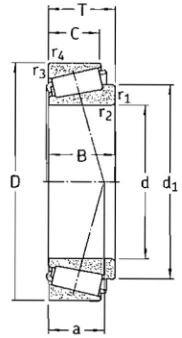


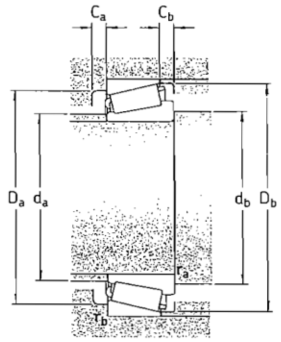


Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designation	Dimension Series to ISO 355 (ABMA)
d	D	T	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	–
15	42	14,25	22,4	20	2,08	13 000	18 000	0,095	**30302 J2**	2FB
17	40	13,25	19	18,6	1,83	13 000	18 000	0,075	**30203 J2**	2DB
	47	15,25	28,1	25	2,75	12 000	16 000	0,13	**30303 J2**	2FB
	47	20,25	34,7	33,5	3,65	11 000	16 000	0,17	**32303 J2/Q**	2FD
20	42	15	24,2	27	2,7	12 000	16 000	0,097	**32004 X/Q**	3CC
	47	15,25	27,5	28	3	11 000	15 000	0,12	**30204 J2/Q**	2DB
	52	16,25	34,1	32,5	3,6	11 000	14 000	0,17	**30304 J2/Q**	2FB
	52	22,25	44	45,5	5	10 000	14 000	0,23	**32304 J2/Q**	2FD
22	44	15	25,1	29	2,85	11 000	15 000	0,10	**320/22 X**	3CC
25	47	15	27	32,5	3,25	11 000	14 000	0,11	**32005 X/Q**	4CC
	52	16,25	30,8	33,5	3,45	10 000	13 000	0,15	**30205 J2/Q**	3CC
	52	19,25	35,8	44	4,65	9 500	13 000	0,19	**32205 BJ2/Q**	5CD
	52	22	47,3	56	6	10 000	13 000	0,23	**33205/Q**	2DE
	62	18,25	44,6	43	4,75	9 000	12 000	0,26	**30305 J2**	2FB
	62	18,25	38	40	4,4	7 500	11 000	0,26	**31305 J2**	7FB
	62	25,25	60,5	63	7,1	8 000	12 000	0,36	**32305 J2**	2FD
28	52	16	31,9	38	4	10 000	13 000	0,15	**320/28 X/Q**	4CC
	58	17,25	38	41,5	4,4	9 000	12 000	0,25	**302/28 J2**	–
	58	20,25	41,8	50	5,5	8 500	12 000	0,25	**322/28 BJ2/Q**	5DD
30	55	17	35,8	44	4,55	9 000	12 000	0,17	**32006 X/Q**	4CC
	62	17,25	40,2	44	4,8	8 500	11 000	0,23	**30206 J2/Q**	3DB
	62	21,25	50,1	57	6,3	8 500	11 000	0,28	**32206 J2/Q**	3DC
	62	21,25	49,5	58,5	6,55	8 000	11 000	0,30	**32206 BJ2/QCL7CVA606**	5DC
	62	25	64,4	76,5	8,5	7 500	11 000	0,37	**33206/Q**	2DE
	72	20,75	56,1	56	6,4	7 500	10 000	0,39	**30306 J2/Q**	2FB
	72	20,75	47,3	50	5,7	6 700	9 500	0,39	**31306 J2/Q**	7FB
	72	28,75	76,5	85	9,65	7 000	10 000	0,55	**32306 J2/Q**	2FD
32	53	14,5	27	35,5	3,65	9 000	12 000	0,11	**JL 26749 F/710**	(L 26700)
	58	17	36,9	46,5	4,8	8 500	11 000	0,19	**320/32 X/Q**	4CC

Dimensions							Abutment and fillet dimensions									Calculation factors		
d	d_1 ~	B	C	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a max	d_b min	D_a min	D_a max	D_b min	C_a min	C_b min	r_a max	r_b max	e	Y	Y_0
mm							mm									–		
15	27,7	13	11	1	1	9	22	21	36	36	38	2	3	1	1	0,28	2,1	1,1
17	28	12	11	1	1	10	23	23	34	34	37	2	2	1	1	0,35	1,7	0,9
	30,4	14	12	1	1	10	25	23	40	41	42	2	3	1	1	0,28	2,1	1,1
	30,7	19	16	1	1	12	24	23	39	41	43	3	4	1	1	0,28	2,1	1,1
20	31,1	15	12	0,6	0,6	10	25	25	36	37	39	2	3	0,6	0,6	0,37	1,6	0,9
	33,2	14	12	1	1	11	27	26	40	41	43	2	3	1	1	0,35	1,7	0,9
	34,3	15	13	1,5	1,5	11	28	27	44	45	47	2	3	1,5	1,5	0,3	2	1,1
	34,5	21	18	1,5	1,5	14	27	27	43	45	47	3	4	1,5	1,5	0,3	2	1,1
22	33,3	15	11,5	0,6	0,6	11	27	27	38	39	41	3	3,5	0,6	0,6	0,40	1,5	0,8
25	36,5	15	11,5	0,6	0,6	11	30	30	40	42	44	3	3,5	0,6	0,6	0,43	1,4	0,8
	37,4	15	13	1	1	12	31	31	44	46	48	2	3	1	1	0,37	1,6	0,9
	40,2	18	15	1	1	16	30	31	41	46	50	3	4	1	1	0,57	1,05	0,6
	38,6	22	18	1	1	14	30	31	43	46	49	4	4	1	1	0,35	1,7	0,9
	41,5	17	15	1,5	1,5	13	34	32	54	55	57	2	3	1,5	1,5	0,3	2	1,1
	45,8	17	13	1,5	1,5	20	34	32	47	55	59	3	5	1,5	1,5	0,83	0,72	0,4
	41,7	24	20	1,5	1,5	15	33	32	52	55	57	3	5	1,5	1,5	0,3	2	1,1
28	40,3	16	12	1	1	12	34	34	45	46	49	3	4	1	1	0,43	1,4	0,8
	41,8	16	14	1	1	13	35	34	50	52	54	2	3	1	1	0,37	1,6	0,9
	43,9	19	16	1	1	17	33	34	46	52	55	3	4	1	1	0,57	1,05	0,6
30	43	17	13	1	1	13	35	36	48	49	52	3	4	1	1	0,43	1,4	0,8
	44,6	16	14	1	1	14	38	36	53	56	57	2	3	1	1	0,37	1,6	0,9
	45,2	20	17	1	1	15	37	36	52	56	58	3	4	1	1	0,37	1,6	0,9
	47,3	20	17	1	1	18	36	36	50	56	60	3	4	1	1	0,57	1,05	0,6
	45,8	25	19,5	1	1	16	36	36	53	56	59	5	5,5	1	1	0,35	1,7	0,9
	48,4	19	16	1,5	1,5	15	41	37	62	65	66	3	4,5	1,5	1,5	0,31	1,9	1,1
	52,7	19	14	1,5	1,5	22	40	37	55	65	68	3	6,5	1,5	1,5	0,83	0,72	0,4
	48,7	27	23	1,5	1,5	18	39	37	59	65	66	3	5,5	1,5	1,5	0,31	1,9	1,1
32	43,6	15	11,5	3,5	1,3	11	38	43	47	47	50	2	3	3	1	0,33	1,8	1
	45,6	17	13	1	1	14	38	38	50	52	55	3	4	1	1	0,46	1,3	0,7

Metric single row tapered roller bearings
d **35 – 40** mm



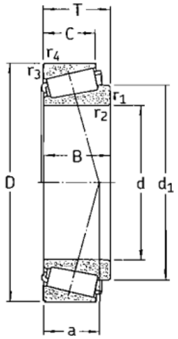


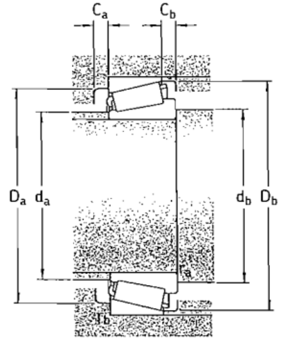
Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designation	Dimension Series to ISO 355 (ABMA)
d	D	T	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	–
35	62	18	42,9	54	5,85	8 500	11 000	0,22	**32007 X/Q**	4CC
	62	18	37,4	49	5,2	8 000	11 000	0,22	**32007 J2/Q**	–
	72	18,25	51,2	56	6,1	7 000	9 500	0,32	**30207 J2/Q**	3DB
	72	24,25	66	78	8,5	7 000	9 500	0,43	**32207 J2/Q**	3DC
	72	28	84,2	106	11,8	6 300	9 500	0,56	**33207/Q**	2DE
	80	22,75	72,1	73,5	8,3	6 700	9 000	0,52	**30307 J2/Q**	2FB
	80	22,75	61,6	67	7,8	6 000	8 500	0,52	**31307 J2/Q**	7FB
	80	32,75	95,2	106	12,2	6 300	9 000	0,73	**32307 J2/Q**	2FE
	80	32,75	93,5	114	13,2	6 000	8 500	0,80	**32307 BJ2/Q**	5FE
37	80	32,75	93,5	114	13,2	6 000	8 500	0,85	**32307/37 BJ2/Q**	–
38	63	17	36,9	52	5,4	7 500	11 000	0,20	**JL 69349 A/310/Q**	(L 69300)
	63	17	36,9	52	5,4	7 500	11 000	0,20	**JL 69349 X/310/Q**	(L 69300)
	63	17	36,9	52	5,4	7 500	11 000	0,19	**JL 69349/310/Q**	(L 69300)
	63	17	36,9	52	5,4	7 500	11 000	0,19	**JL 69345 F/310/Q**	(L 69300)
	68	19	52,8	71	7,65	7 000	9 500	0,28	**32008/38 X/Q**	–
40	68	19	52,8	71	7,65	7 000	9 500	0,27	**32008 X/Q**	3CD
	68	19	52,8	71	7,65	7 000	9 500	0,27	**32008 XTN9/Q**	3CD
	75	26	79,2	104	11,4	6 700	9 000	0,51	**33108/Q**	2CE
	80	19,75	61,6	68	7,65	6 300	8 500	0,42	**30208 J2/Q**	3DB
	80	24,75	74,8	86,5	9,8	6 300	8 500	0,53	**32208 J2/Q**	3DC
	80	32	105	132	15	5 600	8 500	0,77	**33208/QCL7C**	2DE
	85	33	121	150	17,3	6 000	9 000	0,90	**T2EE 040/QVB134**	2EE
	90	25,25	85,8	95	10,8	6 000	8 000	0,72	**30308 J2/Q**	2FB
	90	25,25	85	81,5	9,5	5 600	7 500	0,72	★ **31308 J2/QCL7C**	7FB
	90	35,25	117	140	16	5 300	8 000	1,00	**32308 J2/Q**	2FD

Dimensions							Abutment and fillet dimensions									Calculation factors		
d	d_1 ~	B	C	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a max	d_b min	D_a min	D_a max	D_b min	C_a min	C_b min	r_a max	r_b max	e	Y	Y_0
mm							mm									–		
35	49,2	18	14	1	1	15	41	41	54	56	59	4	4	1	1	0,46	1,3	0,7
	49,5	18	15	1	1	16	41	41	53	56	59	2	3	1	1	0,44	1,35	0,8
	51,8	17	15	1,5	1,5	15	44	42	62	65	67	3	3	1,5	1,5	0,37	1,6	0,9
	52,4	23	19	1,5	1,5	17	43	42	61	65	67	3	5	1,5	1,5	0,37	1,6	0,9
	53,4	28	22	1,5	1,5	18	42	42	61	65	68	5	6	1,5	1,5	0,35	1,7	0,9
	54,5	21	18	2	1,5	16	46	44	70	71	74	3	4,5	2	1,5	0,31	1,9	1,1
	59,6	21	15	2	1,5	25	45	44	62	71	76	3	7,5	2	1,5	0,83	0,72	0,4
	54,8	31	25	2	1,5	20	44	44	66	71	74	4	7,5	2	1,5	0,31	1,9	1,1
	59,3	31	25	2	1,5	24	42	44	61	71	76	4	7,5	2	1,5	0,54	1,1	0,6
37	54,8	31	25	2	1,5	20	44	44	66	71	74	4	7,5	2	1,5	0,54	1,1	0,6
38	52,2	17	13,5	1,3	1,3	14	44	44	55	56,5	60	3	3,5	1	1	0,43	1,4	0,8
	52,2	17	13,5	2,3	1,3	14	44	47	55	56,5	60	3	3,5	2	1	0,43	1,4	0,8
	52,2	17	13,5	3,6	1,3	14	44	50	55	56,5	60	3	3,5	3,5	1	0,43	1,4	0,8
	52,2	19	13,5	3,6	1,3	14	44	50	55	56,5	60	3	3,5	3,5	1	0,43	1,4	0,8
	54,2	19	14,5	1	1	15	46	44	60	62	65	4	4,5	1	1	0,37	1,6	0,9
40	54,2	19	14,5	1	1	15	46	46	60	62	65	4	4,5	1	1	0,37	1,6	0,9
	54,2	19	14,5	1	1	15	46	46	60	62	65	4	4,5	1	1	0,37	1,6	0,9
	57,5	26	20,5	1,5	1,5	18	47	47	65	68	71	4	5,5	1,5	1,5	0,35	1,7	0,9
	57,5	18	16	1,5	1,5	16	49	47	69	73	74	3	3,5	1,5	1,5	0,37	1,6	0,9
	58,4	23	19	1,5	1,5	19	49	47	68	73	75	3	5,5	1,5	1,5	0,37	1,6	0,9
	59,7	32	25	1,5	1,5	21	47	47	67	73	76	5	7	1,5	1,5	0,35	1,7	0,9
	61,2	32,5	28	2,5	2	22	48	50	70	75	80	5	5	2	2	0,35	1,7	0,9
	62,5	23	20	2	1,5	19	53	49	77	81	82	3	5	2	1,5	0,35	1,7	0,9
	67,1	23	17	2	1,5	28	51	49	71	81	86	3	8	2	1,5	0,83	0,72	0,4
	62,9	33	27	2	1,5	23	51	49	73	81	82	3	8	2	1,5	0,35	1,7	0,9

★ SKF Explorer bearing

Metric single row tapered roller bearings
d **45 – 50** mm





Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designation	Dimension Series to ISO 355 (ABMA)
d	D	T	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	–
45	75	20	58,3	80	8,8	6 300	8 500	0,34	**32009 X/Q**	3CC
	80	26	96,5	114	12,9	6 700	8 000	0,56	* **33109/Q**	3CE
	85	20,638	70,4	81,5	9,3	6 000	8 500	0,50	**358 X/354 X/Q**	(355)
	85	20,75	66	76,5	8,65	6 000	8 000	0,48	**30209 J2/Q**	3DB
	85	24,75	91,5	98	11	6 300	8 000	0,58	* **32209 J2/Q**	3DC
	85	32	108	143	16,3	5 300	7 500	0,82	**33209/Q**	3DE
	90	24,75	82,5	104	12,2	5 300	8 000	0,65	**32210/45 BJ2/QVB022**	–
	95	29	89,7	112	12,7	4 800	7 000	0,92	**T7FC 045/HN3QCL7C**	7FC
	95	36	147	186	20,8	5 300	8 000	1,20	**T2ED 045**	2ED
	100	27,25	108	120	14,3	5 300	7 000	0,97	**30309 J2/Q**	2FB
	100	27,25	106	102	12,5	5 000	6 700	0,95	* **31309 J2/QCL7C**	7FB
	100	38,25	140	170	20,4	4 800	7 000	1,35	**32309 J2/Q**	2FD
	100	38,25	134	176	20	4 800	6 700	1,45	**32309 BJ2/QCL7C**	5FD
46	75	18	50,1	71	7,65	6 300	9 500	0,30	**LM 503349/310/QCL7C**	(LM 503300)
50	80	20	60,5	88	9,65	6 000	8 000	0,37	**32010 X/Q**	3CC
	80	20	60,5	88	9,65	6 000	8 000	0,37	**32010 X/QCL7CVB026**	3CC
	80	24	69,3	102	11,4	6 000	8 000	0,45	**33010/Q**	2CE
	82	21,5	72,1	100	11	6 000	8 500	0,43	**JLM 104948 AA/910 AA/Q**	(LM 104900)
	85	26	85,8	122	13,4	5 600	7 500	0,59	**33110/Q**	3CE
	90	21,75	76,5	91,5	10,4	5 600	7 500	0,54	**30210 J2/Q**	3DB
	90	24,75	82,5	100	11,4	5 600	7 500	0,61	**32210 J2/Q**	3DC
	90	28	106	140	16	5 300	8 000	0,75	**JM 205149/110/Q**	(M 205100)
	90	28	106	140	16	5 300	8 000	0,75	**JM 205149/110 A/Q**	(M 205100)
	90	32	114	160	18,3	5 000	7 000	0,90	**33210/Q**	3DE
	100	36	154	200	22,4	5 000	7 500	1,30	**T2ED 050/Q**	2ED
	105	32	108	137	16	4 300	6 300	1,20	**T7FC 050/QCL7C**	7FC
	110	29,25	143	140	16,6	5 300	6 300	1,25	* **30310 J2/Q**	2FB
	110	29,25	122	120	14,3	4 500	6 000	1,20	* **31310 J2/QCL7C**	7FB
	110	42,25	172	212	24	4 300	6 300	1,80	**32310 J2/Q**	2FD
	110	42,25	172	212	24	4 300	6 300	1,80	**32310 TN9**	2FD
	110	42,25	183	216	24,5	4 500	6 000	1,85	* **32310 BJ2/QCL7C**	5FD

* SKF Explorer bearing

Dimensions							Abutment and fillet dimensions									Calculation factors		
d	d_1 ~	B	C	$r_{1,2}$ min	$r_{3,4}$ min	a	d_a max	d_b min	D_a min	D_a max	D_b min	C_a min	C_b min	r_a max	r_b max	e	Y	Y_0
mm							mm									–		
45	60,4	20	15,5	1	1	16	52	51	67	69	72	4	4,5	1	1	0,4	1,5	0,8
	62,7	26	20,5	1,5	1,5	19	52	52	69	73	77	4	5,5	1,5	1,5	0,37	1,6	0,9
	62,4	21,692	17,462	2	1,5	16	55	53	76	77	80	3	3	2	1,5	0,31	1,9	1,1
	63	19	16	1,5	1,5	18	54	52	74	78	80	3	4,5	1,5	1,5	0,4	1,5	0,8
	64	23	19	1,5	1,5	20	54	52	73	78	80	3	5,5	1,5	1,5	0,4	1,5	0,8
	65,2	32	25	1,5	1,5	22	52	52	72	78	81	5	7	1,5	1,5	0,4	1,5	0,8
	68,5	23	19	1,5	0,3	21	58	52	78	87	85	3	5,5	1,5	0,3	0,6	1	0,6
	74	26,5	20	2,5	2,5	32	54	56	71	83	91	3	9	2	2	0,88	0,68	0,4
	68,5	35	30	2,5	2,5	23	55	56	80	83	89	6	6	2	2	0,33	1,8	1
	70,1	25	22	2	1,5	21	59	53	86	91	92	3	5	2	1,5	0,35	1,7	0,9
	74,7	25	18	2	1,5	31	57	53	79	91	95	4	9	2	1,5	0,83	0,72	0,4
	70,4	36	30	2	1,5	25	57	53	82	91	93	4	8	2	1,5	0,35	1,7	0,9
	74,8	36	30	2	1,5	30	55	53	76	91	94	5	8	2	1,5	0,54	1,1	0,6
46	60,4	18	14	2,3	1,5	16	53	55	67	67,5	71	2	4	2	1,5	0,4	1,5	0,8
50	65,6	20	15,5	1	1	18	57	56	72	74	77	4	4,5	1	1	0,43	1,4	0,8
	65,6	20	15,5	3	1	18	57	62	72	74	77	4	4,5	2,5	1	0,43	1,4	0,8
	64,9	24	19	1	1	17	56	56	72	74	76	4	5	1	1	0,31	1,9	1,1
	65,1	21,5	17	3,6	1,2	16	57	62	74	76	78	4	4,5	3,4	1,2	0,3	2	1,1
	67,9	26	20	1,5	1,5	20	57	57	74	78	82	4	6	1,5	1,5	0,4	1,5	0,8
	67,9	20	17	1,5	1,5	19	58	57	79	83	85	3	4,5	1,5	1,5	0,43	1,4	0,8
	68,5	23	19	1,5	1,5	21	58	57	78	83	85	3	5,5	1,5	1,5	0,43	1,4	0,8
	68,7	28	23	3	2,5	20	58	64	78	78	85	5	5	2,5	2	0,33	1,8	1
	68,7	28	23	3	0,8	20	58	64	78	85	85	5	5	2,5	0,6	0,33	1,8	1
	70,7	32	24,5	1,5	1,5	23	57	57	77	83	87	5	7,5	1,5	1,5	0,4	1,5	0,8
	73,5	35	30	2,5	2,5	25	59	60	84	88	94	6	6	2	2	0,35	1,7	0,9
	81	29	22	3	3	36	60	62	78	91	100	4	10	2,5	2,5	0,88	0,68	0,4
	77,2	27	23	2,5	2	23	65	60	95	100	102	4	6	2	2	0,35	1,7	0,9
	81,5	27	19	2,5	2	34	62	60	87	100	104	4	10	2	2	0,83	0,72	0,4
	77,7	40	33	2,5	2	27	63	60	90	100	102	5	9	2	2	0,35	1,7	0,9
	77,7	40	33	2,5	2	27	63	60	90	100	102	5	9	2	2	0,35	1,7	0,9
	82,9	40	33	2,5	2	34	62	60	83	100	103	5	9	2	2	0,54	1,1	0,6

Influence of operating temperature on bearing material

All SKF spherical roller bearings undergo a special heat treatment so that they can be operated at higher temperatures for longer periods, without the occurrence of inadmissible dimensional changes. For example, a temperature of +200 °C for 2 500 h, or for short periods at even higher temperatures, is permitted.

Axial load carrying capacity

Because of their special internal design, SKF spherical roller bearings are able to accommodate heavy axial loads and even purely axial loads.

Axial load carrying capacity of bearings mounted on an adapter sleeve

If spherical roller bearings with adapter sleeves are mounted on smooth shafts with no fixed abutment, the magnitude of the axial load that can be supported is determined by the friction between the shaft and sleeve. Provided the bearings are correctly mounted, the permissible axial load can be calculated from

$$F_{ap} = 0{,}003\ B\ d$$

where
F_{ap} = maximum permissible axial load, kN
B = bearing width, mm
d = bearing bore diameter, mm

Minimum load

In order to provide satisfactory operation, spherical roller bearings, like all ball and roller bearings, must always be subjected to a given minimum load, particularly if they are to operate at high speeds or are subjected to high accelerations or rapid changes in the direction of load. Under such conditions, the inertia forces of the rollers and cage(s), and the friction in the lubricant, can have a detrimental influence on the rolling conditions in the bearing arrangement and may cause damaging sliding movements to occur between the rollers and raceways.

The requisite minimum load to be applied to spherical roller bearings can be estimated using

$$P_m = 0{,}01\ C_0$$

where
P_m = equivalent minimum load, kN
C_0 = basic static load rating, kN
(→ product tables)

In some applications it is not possible to reach or exceed the requisite minimum load. However, if the bearing is oil lubricated lower minimum loads are permissible. These loads can be calculated when $n/n_r \leq 0{,}3$ from

$$P_m = 0{,}003\ C_0$$

and when $0{,}3 < n/n_r \leq 2$ from

$$P_m = 0{,}003\ C_0 \left(1 + 2\sqrt{\frac{n}{n_r} - 0{,}3}\right)$$

where
P_m = equivalent minimum load, kN
C_0 = basic static load rating, kN
(→ product tables)
n = rotational speed, r/min
n_r = reference speed, r/min
(→ product tables)

When starting up at low temperatures or when the lubricant is highly viscous, even greater minimum loads than $P_m = 0{,}01\ C_0$ may be required. The weight of the components supported by the bearing, together with external forces, generally exceeds the requisite minimum load. If this is not the case, the spherical roller bearing must be subjected to an additional radial load.

NoWear spherical roller bearings have proven to give reliable operation at very low loads. They can withstand longer periods of insufficient lubrication, sudden variations in load and rapid speed changes (→ **page 943**).

Equivalent dynamic bearing load

$P = F_r + Y_1 F_a$ when $F_a/F_r \leq e$
$P = 0{,}67\ F_r + Y_2 F_a$ when $F_a/F_r > e$

The values of the calculation factors e, Y_1 and Y_2 can be found in the product tables.

Equivalent static bearing load

$P_0 = F_r + Y_0 F_a$

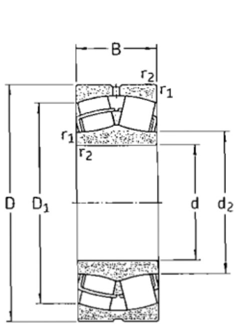
The value of the calculation factor Y_0 can be found in the product tables.

Supplementary designations

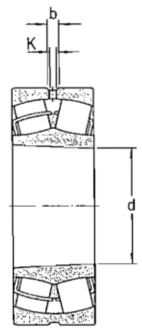
The designation suffixes used to identify certain features of SKF spherical roller bearings are explained in the following. The suffixes used to identify bearing (and cage) design, e.g. CC or E, are not included here as they are explained in the section "Standard bearings" on **page 696**.

C2	Radial internal clearance smaller than Normal
C3	Radial internal clearance greater than Normal
C4	Radial internal clearance greater than C3
C5	Radial internal clearance greater than C4
C08	Heightened running accuracy to ISO tolerance class 5
C083	C08 + C3
C084	C08 + C4
2CS	Sheet steel reinforced contact seal of acrylonitrile-butadiene rubber (NBR) on both sides of the bearing. Annular groove and three lubrication holes in the outer ring covered with a polymer band. Lubricated with an extreme pressure bearing grease according to **table 1** on **page 698**
2CS2	Sheet steel reinforced contact seal of fluoro rubber (FKM) on both sides of the bearing. Annular groove and three lubrication holes in the outer ring; covered with a polymer band. Lubricated with a polyurea high-temperature grease
2CS5	Sheet steel reinforced contact seal of hydrogenated acrylonitrile-butadiene rubber (HNBR) on both sides of the bearing. Otherwise as 2CS2
HA3	Case-hardened inner ring
K	Tapered bore, taper 1:12
K30	Tapered bore, taper 1:30
P5	Dimensional and running accuracy to ISO tolerance class 5
P6	Dimensional and running accuracy to ISO tolerance class 6
P62	P6 + C2
VA405	Bearings for vibratory applications with surface hardened cages
VA406	VA405 and PTFE-coated bore
VE552(E)	Outer ring with three equally spaced threaded holes in one side face to accommodate hoisting tackle; the E indicates that appropriate eye bolts are supplied with the bearings
VE553(E)	As VE552 but with threaded holes in both side faces
VG114	Surface hardened pressed steel cage
VQ424	Running accuracy better than C08
VT143	Grease fill with an extreme pressure grease according to **table 1** on **page 698**
W	Without annular groove and lubrication holes in outer ring
W20	Three lubrication holes in the outer ring
W26	Six lubrication holes in the inner ring
W33	Annular groove and three lubrication holes in the outer ring
W33X	Annular groove and six lubrication holes in the outer ring
W64	Solid Oil filling
W77	Plugged W33 lubrication holes
W513	W26 + W33
235220	Case-hardened inner ring with helical groove in the bore

Spherical roller bearings
d **20 – 70** mm



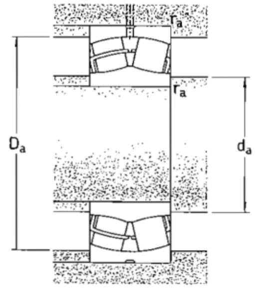
Cylindrical bore



Tapered bore

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designations Bearing with cylindrical bore	tapered bore
d	D	B	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	
20	52	18	49	44	4,75	13 000	17 000	0,28	**★ 22205/20 E**	–
25	52	18	49	44	4,75	13 000	17 000	0,26	**★ 22205 E**	**★ 22205 EK**
	62	17	41,4	41,5	4,55	8 500	12 000	0,28	**21305 CC**	–
30	62	20	64	60	6,4	10 000	14 000	0,29	**★ 22206 E**	**★ 22206 EK**
	72	19	55,2	61	6,8	7 500	10 000	0,41	**21306 CC**	**21306 CCK**
35	72	23	86,5	85	9,3	9 000	12 000	0,45	**★ 22207 E**	**★ 22207 EK**
	80	21	65,6	72	8,15	6 700	9 500	0,55	**21307 CC**	**21307 CCK**
40	80	23	96,5	90	9,8	8 000	11 000	0,53	**★ 22208 E**	**★ 22208 EK**
	90	23	104	108	11,8	7 000	9 500	0,75	**★ 21308 E**	**★ 21308 EK**
	90	33	150	140	15	6 000	8 000	1,05	**★ 22308 E**	**★ 22308 EK**
45	85	23	102	98	10,8	7 500	10 000	0,58	**★ 22209 E**	**★ 22209 EK**
	100	25	125	127	13,7	6 300	8 500	0,99	**★ 21309 E**	**★ 21309 EK**
	100	36	183	183	19,6	5 300	7 000	1,40	**★ 22309 E**	**★ 22309 EK**
50	90	23	104	108	11,8	7 000	9 500	0,63	**★ 22210 E**	**★ 22210 EK**
	110	27	156	166	18,6	5 600	7 500	1,35	**★ 21310 E**	**★ 21310 EK**
	110	40	220	224	24	4 800	6 300	1,90	**★ 22310 E**	**★ 22310 EK**
55	100	25	125	127	13,7	6 300	8 500	0,84	**★ 22211 E**	**★ 22211 EK**
	120	29	156	166	18,6	5 600	7 500	1,70	**★ 21311 E**	**★ 21311 EK**
	120	43	270	280	30	4 300	5 600	2,45	**★ 22311 E**	**★ 22311 EK**
60	110	28	156	166	18,6	5 600	7 500	1,15	**★ 22212 E**	**★ 22212 EK**
	130	31	212	240	26,5	4 800	6 300	2,10	**★ 21312 E**	**★ 21312 EK**
	130	46	310	335	36,5	4 000	5 300	3,10	**★ 22312 E**	**★ 22312 EK**
65	100	35	132	173	20,4	4 300	6 300	0,95	**★ 24013 CC/W33**	**★ 24013 CCK30/W33**
	120	31	193	216	24	5 000	7 000	1,55	**★ 22213 E**	**★ 22213 EK**
	140	33	236	270	29	4 300	6 000	2,55	**★ 21313 E**	**★ 21313 EK**
	140	48	340	360	38	3 800	5 000	3,75	**★ 22313 E**	**★ 22313 EK**
70	125	31	208	228	25,5	5 000	6 700	1,55	**★ 22214 E**	**★ 22214 EK**
	150	35	285	325	34,5	4 000	5 600	3,10	**★ 21314 E**	**★ 21314 EK**
	150	51	400	430	45	3 400	4 500	4,55	**★ 22314 E**	**★ 22314 EK**

★ SKF Explorer bearing



Dimensions						Abutment and fillet dimensions			Calculation factors			
d	d_2 ~	D_1 ~	b	K	$r_{1,2}$ min	d_a min	D_a max	r_a max	e	Y_1	Y_2	Y_0
mm						mm			–			
20	31,2	44,2	3,7	2	1	25,6	46,4	1	0,35	1,9	2,9	1,8
25	31,2	44,2	3,7	2	1	30,6	46,4	1	0,35	1,9	2,9	1,8
	35,7	50,7	–	–	1,1	32	55	1	0,30	2,3	3,4	2,2
30	37,5	53	3,7	2	1	35,6	56,4	1	0,31	2,2	3,3	2,2
	43,3	58,8	–	–	1,1	37	65	1	0,27	2,5	3,7	2,5
35	44,5	61,8	3,7	2	1,1	42	65	1	0,31	2,2	3,3	2,2
	47,2	65,6	–	–	1,5	44	71	1,5	0,28	2,4	3,6	2,5
40	49,1	69,4	5,5	3	1,1	47	73	1	0,28	2,4	3,6	2,5
	59,9	79,8	5,5	3	1,5	49	81	1,5	0,24	2,8	4,2	2,8
	49,7	74,3	5,5	3	1,5	49	81	1,5	0,37	1,8	2,7	1,8
45	54,4	74,4	5,5	3	1,1	52	78	1	0,26	2,6	3,9	2,5
	65,3	88	5,5	3	1,5	54	91	1,5	0,24	2,8	4,2	2,8
	56,4	83,4	5,5	3	1,5	54	91	1,5	0,37	1,8	2,7	1,8
50	59,9	79	5,5	3	1,1	57	83	1	0,24	2,8	4,2	2,8
	71,6	96,8	5,5	3	2	61	99	2	0,24	2,8	4,2	2,8
	62,1	91,9	5,5	3	2	61	99	2	0,37	1,8	2,7	1,8
55	65,3	88	5,5	3	1,5	64	91	1,5	0,24	2,8	4,2	2,8
	71,6	96,2	5,5	3	2	66	109	2	0,24	2,8	4,2	2,8
	70,1	102	5,5	3	2	66	109	2	0,35	1,9	2,9	1,8
60	71,6	96,5	5,5	3	1,5	69	101	1,5	0,24	2,8	4,2	2,8
	87,8	115	5,5	3	2,1	72	118	2	0,22	3	4,6	2,8
	77,9	110	8,3	4,5	2,1	72	118	2	0,35	1,9	2,9	1,8
65	73,8	87,3	3,7	2	1,1	71	94	1	0,27	2,5	3,7	2,5
	77,6	106	5,5	3	1,5	74	111	1,5	0,24	2,8	4,2	2,8
	94,7	124	5,5	3	2,1	77	128	2	0,22	3	4,6	2,8
	81,6	118	8,3	4,5	2,1	77	128	2	0,35	1,9	2,9	1,8
70	83	111	5,5	3	1,5	79	116	1,5	0,23	2,9	4,4	2,8
	101	133	5,5	3	2,1	82	138	2	0,22	3	4,6	2,8
	90,3	128	8,3	4,5	2,1	82	138	2	0,33	2	3	2

Seals

Bearings must be protected by suitable seals (either single seals or combinations of seals) against the entry of solid contaminants or moisture and to prevent lubricant leakage from the bearing position. The efficiency of the sealing arrangement has a decisive effect on the operational life of a bearing.

Many factors must be considered when selecting the best sealing arrangement for a bearing application, e.g. the type of lubrication (oil or grease), peripheral speed at the sealing surface, possible misalignment of the shaft, available space, friction of the seal and resultant temperature rise, and cost.

Two basic types of seal are normally used for rolling bearings; the more important designs are shown on the following pages.

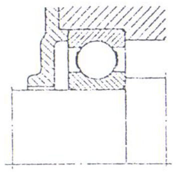
Non-rubbing seals

The effectiveness of non-rubbing seals depends in principle on the sealing action of narrow gaps, which may be arranged axially, radially, or axially and radially in combination. This type of seal has negligible friction and wear and is not easily damaged. It is particularly suitable for high speeds and temperatures.

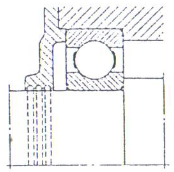
The most simple form of gap-type seal, which is adequate for machines in dry and dust-free surroundings, consists of a smooth gap (a) at the exit of the shaft from the housing. The sealing efficiency of this seal can be enhanced for grease lubrication by machining one or more concentric grooves in the housing bore at the shaft exit (b). The grease emerging through the gap fills the grooves and helps to prevent the entry of contaminants.

With oil lubrication and horizontal shafts, helical grooves – right or left-hand depending on the direction of rotation of the shaft – can be provided in the shaft or seal bore (c). These serve to return emerging oil to the bearing position. It is essential, however, that the direction of rotation of the shafts is constant.

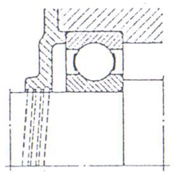
Single or multi-stage labyrinths are considerably more efficient than simple gap-type seals, but are more expensive to



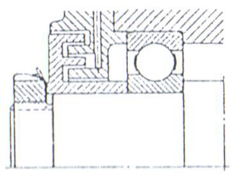
a



b



c



d

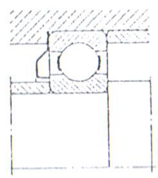
ings. They are either clamped against the outer ring (f) or the inner ring and exert a resilient pressure axially on the other bearing ring.

Combined seals

Where arduous operating conditions (e.g. severe contamination or large amounts of water) place high demands on sealing efficiency, rubbing and non-rubbing seals are often combined. The non-rubbing seals (labyrinths, flingers etc.) are used in such cases to protect the rubbing seals from wear and mechanical damage.

Sealed and shielded bearings

Simple, space-saving arangements can be achieved using bearings fitted with seals or shields at both sides. Bearings with two seals or shields are supplied filled with the correct quantity of grease. They are maintenance-free and are primaily used in applications where other sealing arrangements are inadequate or where, for space reasons, separate seals cannot be provided. These "lubricated-for-life" bearings can be found in the sections "Deep groove ball bearings", "Self-aligning ball bearings", "Full complement cylindrical roller bearings", "Y-bearing units" and "Track runner bearings".

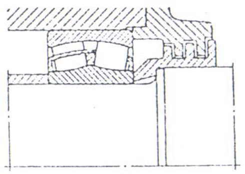


f

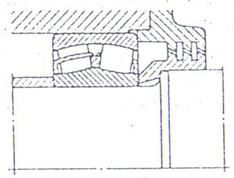
manufacture. They are chiefly used with grease lubrication. Their efficiency can be further improved by periodically supplying a water-insoluble grease, e.g. a lithium or calcium base grease (see page 90), via a duct to the labyrinth passages. The tongues of the labyrinth seal are arranged axially (d) for one-piece housings and radially (e) for split housings. The width of the axial passages of the labyrinth remains unchanged when axial displacements of the shaft occur in operation and can thus be made very small. If angular misalignment of the shaft with respect to the housing can occur, labyrinths with inclined passages (f) are used.

An effective but inexpensive labyrinth seal can be made using SKF sealing washers (g). Further details will be found in the section entitled "Accessories". Sealing efficiency increases with the number of washer sets used, or can be improved by incorporating flocked sealing washers.

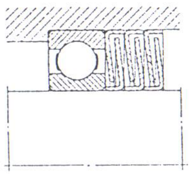
Rotating discs (h) are often fitted to the shaft to enhance the sealing action of non-rubbing seals, and flingers (i) are used for the same purpose with oil lubrication. The oil from the flinger is collected in a channel in the housing.seal bore and returned to the housing through suitable ducts.



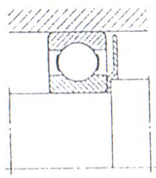
e



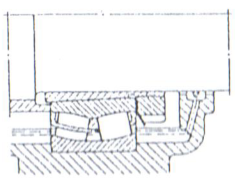
f



g



h



i

Rubbing seals

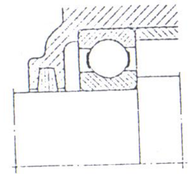
The action of rubbing seals depends on the seal exerting a certain pressure, by virtue of its elasticity, at the seal/sealing surface contact. The usefulness of the various seal designs and the sealing surface quality required depend on the peripheral speed.

Felt seals (a) are generally used with grease lubrication, for example, to seal plummer blocks. This type of seal is simple and inexpensive and can be used at peripheral speeds up to 4 m/s and operating temperatures up to 100 °C. If supplemented by a simple labyrinth (b) a considerable improvement in sealing efficiency can be achieved. The felt rings or strips should be soaked in hot oil (about 80 °C) before being inserted in the housing groove.

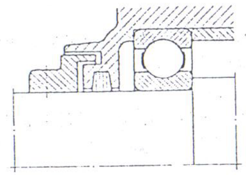
Where greater demands are made on sealing efficiency, particularly with oil lubrication, radial lip-type seals are often used in preference to felt seals. Radial lip-type seals are ready-to-mount components with a sealing lip of synthetic rubber or plastic and usually have a sheet metal casing. At peripheral speeds above 4 m/s the sealing surface should be ground and above 8 m/s the surface should preferably be hardened or hard chromium plated, and fine ground or polished. If the main purpose is to prevent lubricant leakage from the housing, then the lip should face inwards (c); to prevent entry of contaminants, the seal should be mounted with its lip facing outwards (d).

The V-ring seal (e) can be used with grease or oil lubrication. The V-ring has a rubber body and its sealing lip exerts a light axial pressure on the sealing surface. This type of seal is simple to fit and at slow speeds permits relatively large angular misalignments of the shaft with respect to the housing. It can also be used for high peripheral speeds if properly located. Its effectiveness owes much to the flinger action of the rotating ring. With grease lubrication it is therefore generally fitted on the outside of the housing and for oil lubrication on the inside of the housing.

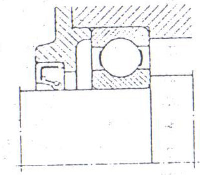
Resilient washers provide a simple, cheap and [illegible]e-saving seal, especially for grease-lubri[illegible]ed deep groove ball bear-



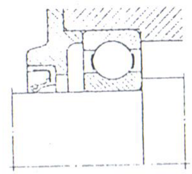
a



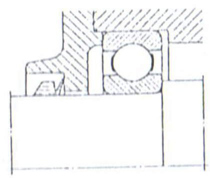
b



c

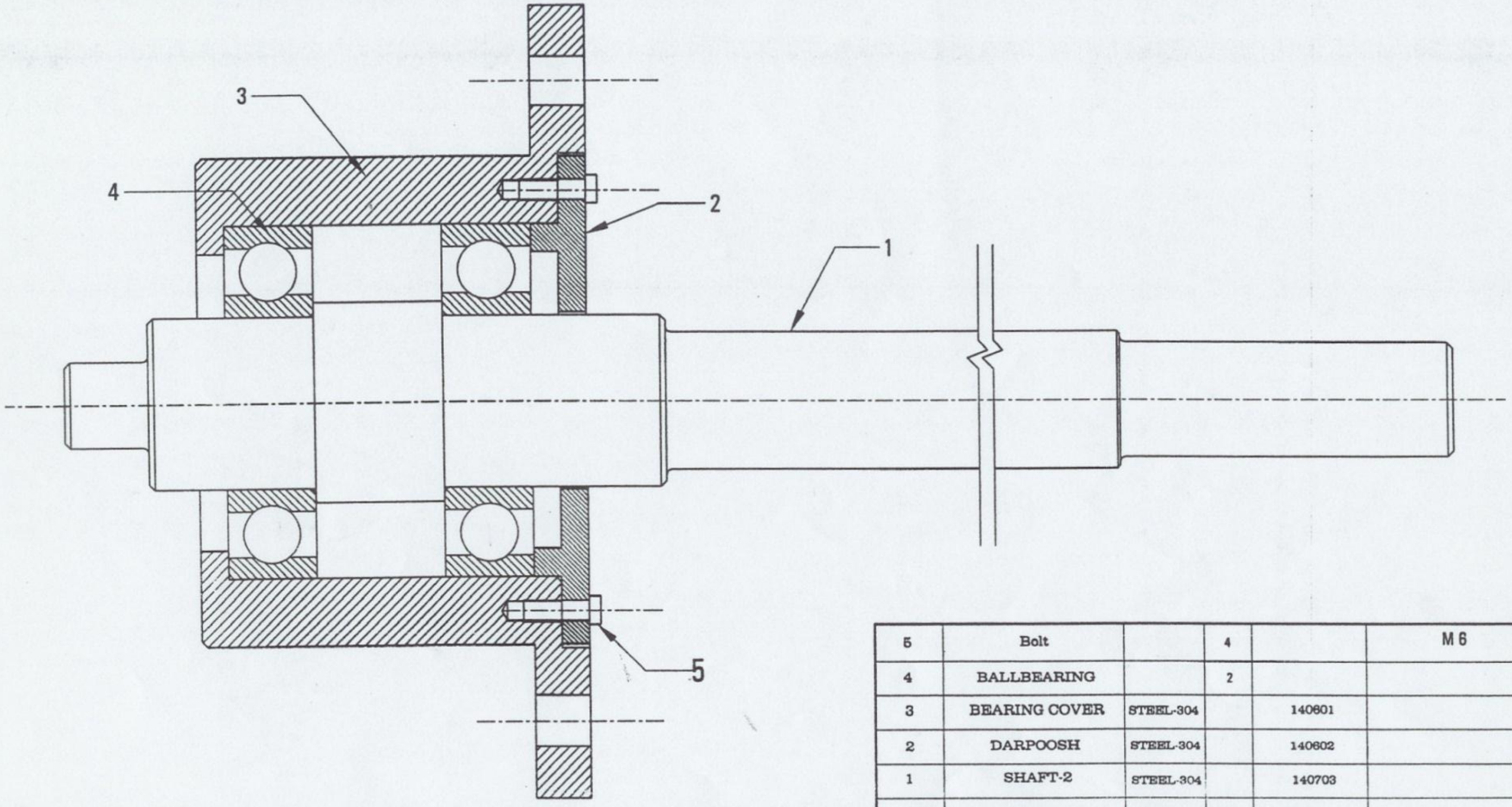


d



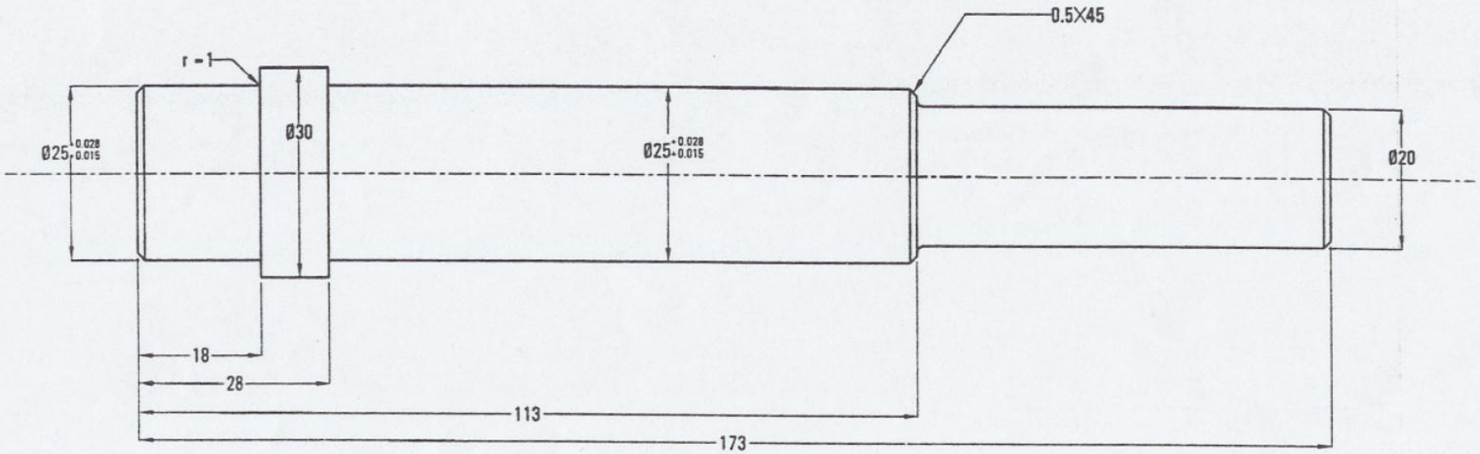
e

۲. نمونه نقشه کارگاهی

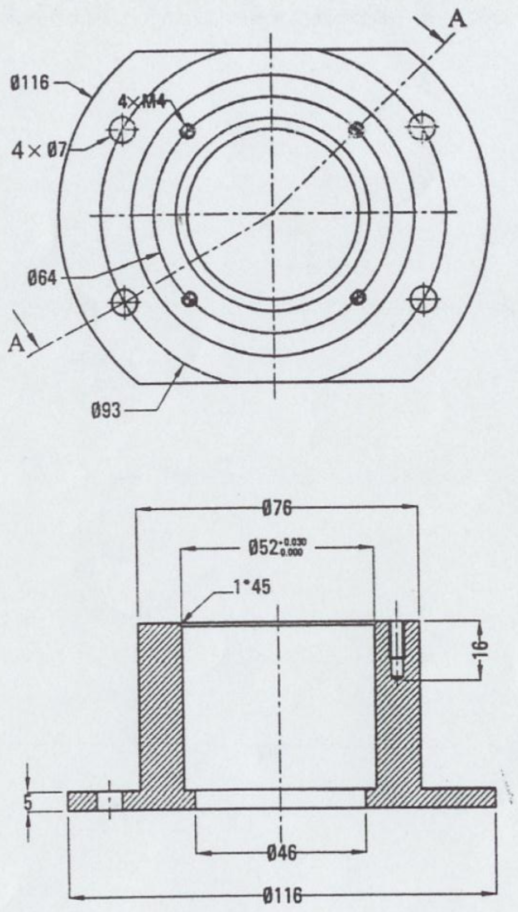


NO.	REMARKS	MAT.	QUAN.	DWG.NO.	
5	Bolt		4		M 6
4	BALLBEARING		2		
3	BEARING COVER	STEEL-304		140601	
2	DARPOOSH	STEEL-304		140602	
1	SHAFT-2	STEEL-304		140703	

TITLE: Assemble of Rekab				CUSTOMER	PROJECT: Generator - Pe Model
DWG.NO.: 140700				SCALE 1:1	PROJECTION
DRAWN	DESIGNED	CHECKED	APPROVED	Tol	DIN 7168 M
				Date	1384/03/03

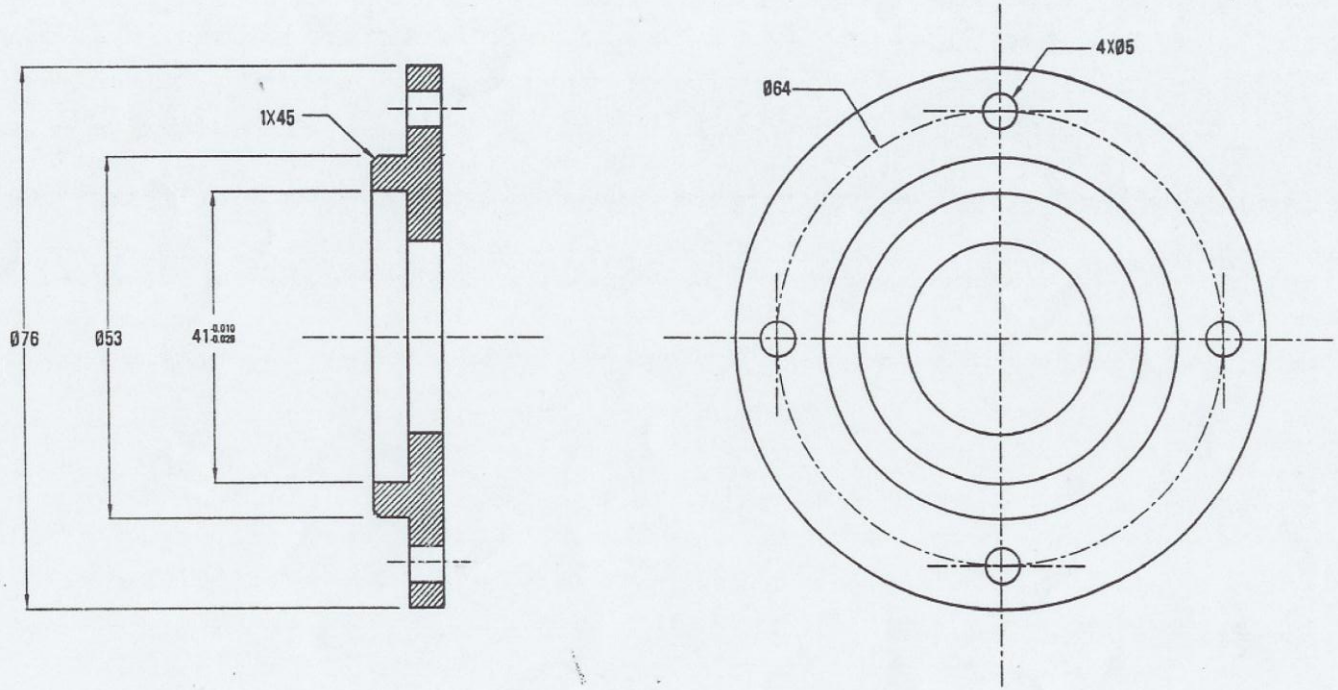


MAT.	Steel 304	QUAN.	1	DESCRIPTION	
TITLE: Shaft of Handle				CUSTOMER	PROJECT
					Generator - Ha Model
DWG.NO.: 150301				SCALE 1:1	PROJECTION ⊕
DRAWN	DESIGNED	CHECKED	APPROVED	Tol DIN 7168 M	
				Date 1384/03/03	



VIEW A:A

MAT.	Steel 304	QUAN.	1	DESCRIPTION		
TITLE: BEARING COVER				CUSTOMER		PROJECT
						Generator - Ha Model
DWG.NO.: 150302				SCALE	1:2	PROJECTION
DRAWN	DESIGNED	CHECKED	APPROVED	Tol	DIN 7168 M	
				Date	1384/03/03	



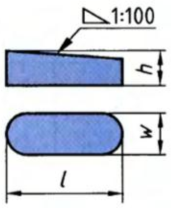
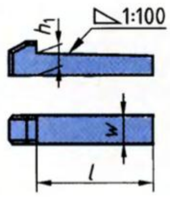
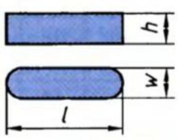
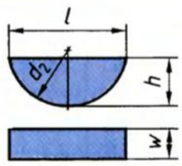
MAT.	STEEL-304	QUAN.	2	DESCRIPTION		
TITLE: Darpoosh(LED)				CUSTOMER		PROJECT Generator - Ha Model
DWG.NO.: 150303				SCALE	1:1	PROJECTION
DRAWN	DESIGNED	CHECKED	APPROVED	Tol	DIN 7168 M	
				Date	1384/03/03	

۳. انتخاب خار

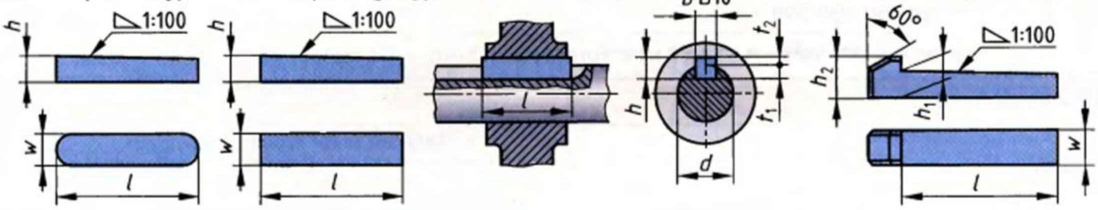
Keys, Gib-head keys

Designation example: Feather key DIN 6885 – A – 12x8x56 – E295

Name | Standard | Form or Type | Width x height x length | Material, e.g. steel

Illustration	Designation, Standard range from–to	Standard	Illustration	Designation, Standard range from–to	Standard
Overview of tapered keys					table below
	Tapered key $w \times h$ = 2 x 2–100 x 50	DIN 6886 Form A: sunk key Form B: driving key		Gib-head tapered key $w \times h$ = 4 x 4–100 x 50	DIN 6887
Overview of feather keys					page 240
Form A 	Feather key $w \times h$ = 2 x 2–100 x 50	DIN 6885 Form A–J		Woodruff keys $w \times h$ = 2.5x3.7–10x16	DIN 6888

Tapered keys, Gib-head tapered keys cf. DIN 6886 (1967-12) or DIN 6887 (1968-04)



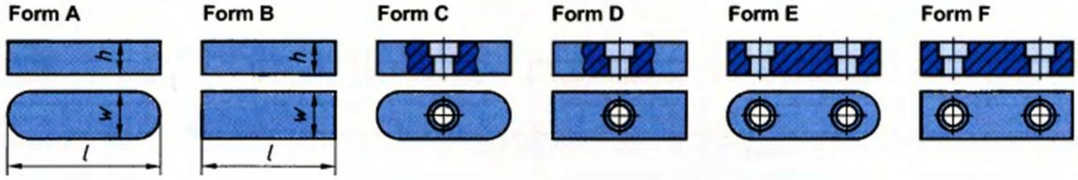
For shaft diameter d	over / to	10 12	12 17	17 22	22 30	30 38	38 44	44 50	50 58	58 65	65 75	75 85	85 95	95 110
Tapered keys	w D10 h	4 4	5 5	6 6	8 7	10 8	12 8	14 9	16 10	18 11	20 12	22 14	25 14	28 16
Gib-head tapered keys	h_1 h_2	4.1 7	5.1 8	6.1 10	7.2 11	8.2 12	8.2 12	9.2 14	10.2 16	11.2 18	12.2 20	14.2 22	14.2 22	16.2 25
Shaft keyway depth Hub keyway depth	t_1 t_2	2.5 1.2	3 1.7	3.5 2.2	4 2.4	5 2.4	5 2.4	5.5 2.9	6 3.4	7 3.4	7.5 3.9	9 4.4	9 4.4	10 5.4
Allow. deviation	t_1, t_2	+0.1			+0.2									
Key length l	from to	10[1] 45	12[1] 56	16 70	20 90	25 110	32 140	40 160	45 180	50 200	56 220	63 250	70 280	80 320
Nominal lengths l		6, 8–20, 22, 25, 28, 32, 40, 45, 50, 56, 63, 70, 80–100, 110, 125, 140, 160–200, 220, 250, 280, 320, 360, 400 mm												

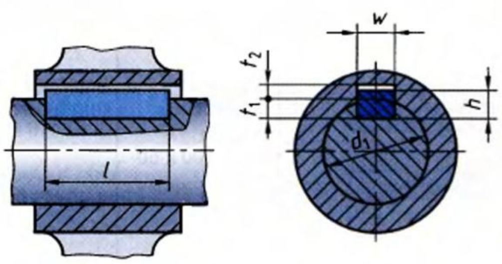
Length tolerances	Key length l, from–to	6–28	32–80	90–400
Tolerances for	Key length	–0.2	–0.3	–0.5
	Keyway length (sunk key)	+0.2	+0.3	+0.5

[1] Gib-head key lengths from 14 mm

Feather keys, Woodruff keys

Feather keys (high form) — cf. DIN 6885-1 (1968-08)

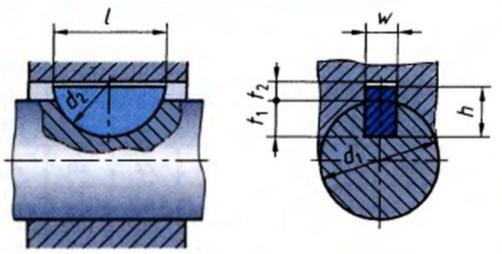




Tolerances for feather keyways			
Shaft keyway width w	tight fit normal fit		P 9 N 9
Hub keyway width w	tight fit normal fit		P 9 JS 9
Allow. deviation for d_1	≤ 22	≤ 130	> 130
Shaft keyway depth t_1 Hub keyway depth t_2	+0.1 +0.1	+0.2 +0.2	+0.3 +0.3
Alllow. deviation for length l	6–28	32–80	90–400
Length tolerances for key	–0.2	–0.3	–0.5
Length tolerances for keyway	+0.2	+0.3	+0.5

d_1 over to	6 8	8 10	10 12	12 17	17 22	22 30	30 38	38 44	44 50	50 58	58 65	65 75	75 85	85 95	95 110	110 130
w h	2 2	3 3	4 4	5 5	6 6	8 7	10 8	12 8	14 9	16 10	18 11	20 12	22 14	25 14	28 16	32 18
t_1 t_2	1.2 1	1.8 1.4	2.5 1.8	3 2.3	3.5 2.8	4 3.3	5 3.3	5 3.3	5.5 3.8	6 4.3	7 4.4	7.5 4.9	9 5.4	9 5.4	10 6.4	11 7.4
l from to	6 20	6 36	8 45	10 56	14 70	18 90	20 110	28 140	36 160	45 180	50 200	56 220	63 250	70 280	80 320	90 360
Nominal lengths l	6, 8, 10, 12, 14, 16, 18, 20, 22, 25, 28, 32, 36, 40, 45, 50, 56, 63, 70, 80, 90, 100, 110, 125, 140, 160, 180, 200, 220, 250, 280, 320 mm															
⇒	**Feather key DIN 6885 – A – 12 x 8 x 56**: Form A, b = 12 mm, h = 8 mm, l = 56 mm															

Woodruff keys — cf. DIN 6888 (1956-08)



Tolerances for Woodruff keyways						
Shaft keyway width w	tight fit normal fit			P 9 (P 8)[1] N 9 (N 8)[1]		
Hub keyway width w	tight fit normal fit			P 9 (P 8)[1] J 9 (J 8)[1]		
Allow. devia. for w and h	≤ 5 ≤ 7.5	5 > 7.5	6 ≤ 9	6 > 9	8 –	10 –
Shaft keyway depth t_1 Hub keyway depth t_2	+0.1 +0.1	+0.2 +0.1	+0.1 +0.1	+0.2 +0.1	+0.2 +0.1	+0.2 +0.2

d_1 over to	8 10				10 12			12 17			17 22			22 30			30 38		
w h9	2.5	3			4			5			6			8			10		
h h12	3.7	3.7	5	6.5	5	6.5	7.5	6.5	7.5	9	7.5	9	11	9	11	13	11	13	16
d_2	10	10	13	16	13	16	19	16	19	22	19	22	28	22	28	32	28	32	45
t_1	2.9	2.5	3.8	5.3	3.5	5	6	4.5	5.5	7	5.1	6.6	8.6	6.2	8.2	10.2	7.8	9.8	12.8
t_2	1	1.4			1.7			2.2			2.6			3			3.4		
l ≈	9.7	9.7	12.7	15.7	12.7	15.7	18.6	15.7	18.6	21.6	18.6	21.6	27.4	21.6	27.4	31.4	27.4	31.4	43.1
⇒	**Woodruff key DIN 6888 – 6 x 9:** w = 6 mm, h = 9 mm																		

[1] Tolerance class for broached keyways

٤ . تلرانس

ISO fits																
Basic hole system																cf. DIN ISO 286-2 (1990-11)
Nominal dimension range over–to mm	Limit deviations in µm for tolerance classes[1]															
	for hole	for shafts Paired with an H6 hole results in a					for hole	for shafts Paired with an H7 hole results in a								
		clearance, transition, interference fit						clearance fit			transition fit				interference fit	
	H6	h5	j5	k6	n5	**r5**	**H7**	**f7**	g6	**h6**	j6	k6	m6	**n6**	**r6**	s6
up to 3	+6 0	0 −4	±2	+6 0	+8 +4	+14 +10	+10 0	−6 −16	−2 −8	0 −6	+4 −2	+6 0	+8 +2	+10 +4	+16 +10	+20 +14
3–6	+8 0	0 −5	+3 −2	+9 +1	+13 +8	+20 +15	+12 0	−10 −22	−4 −12	0 −8	+6 −2	+9 +1	+12 +4	+16 + 8	+23 +15	+27 +19
6–10	+9 0	0 −6	+4 −2	+10 +1	+16 +10	+25 +19	+15 0	−13 −28	−5 −14	0 −9	+7 −2	+10 +1	+15 +6	+19 +10	+28 +19	+32 +23
10–14 14–18	+11 0	0 −8	+5 −3	+12 +1	+20 +12	+31 +23	+18 0	−16 −34	−6 −17	0 −11	+8 −3	+12 +1	+18 +7	+23 +12	+34 +23	+39 +28
18–24 24–30	+13 0	0 −9	+5 −4	+15 +2	+24 +15	+37 +28	+21 0	−20 −41	−7 −20	0 −13	+9 −4	+15 +2	+21 +8	+28 +15	+41 +28	+48 +35
30–40 40–50	+16 0	0 −11	+6 −5	+18 +2	+28 +17	+45 +34	+25 0	−25 −50	−9 −25	0 −16	+11 −5	+18 +2	+25 +9	+33 +17	+50 +34	+59 +43
50–65 65–80	+19 0	0 −13	+6 −7	+21 +2	+33 +20	+54 +41 +56 +43	+30 0	−30 −60	−10 −29	0 −19	+12 −7	+21 +2	+30 +11	+39 +20	+60 +41 +62 +43	+72 +53 +78 +59
80–100 100–120	+22 0	0 −15	+6 −9	+25 +3	+38 +23	+66 +51 +69 +54	+35 0	−36 −71	−12 −34	0 −22	+13 −9	+25 +3	+35 +13	+45 +23	+73 +51 +76 +54	+93 +71 +101 +79
120–140 140–160 160–180	+25 0	0 −18	+7 −11	+28 +3	+45 +27	+81 +63 +83 +65 +86 +68	+40 0	−43 −83	−14 −39	0 −25	+14 −11	+28 +3	+40 +15	+52 +27	+88 +63 +90 +65 +93 +68	+117 +92 +125 +100 +133 +108
180–200 200–225 225–250	+29 0	0 −20	+ 7 −13	+33 +4	+51 +31	+97 +77 +100 +80 +104 +84	+46 0	−50 −96	−15 −44	0 −29	+16 −13	+33 +4	+46 +17	+60 +31	+106 +77 +109 +80 +113 +84	+151 +122 +159 +130 +169 +140
250–280 280–315	+32 0	0 −23	+7 −16	+36 +4	+57 +34	+117 +94 +121 +98	+52 0	−56 −108	−17 −49	0 −32	+16 −16	+36 +4	+52 +20	+66 +34	+126 +94 +130 +98	+190 +158 +202 +170
315–355 355–400	+36 0	0 −25	+7 −18	+40 +4	+62 +37	+133 +108 +139 +114	+57 0	−62 −119	−18 −54	0 −36	+18 −18	+40 +4	+57 +21	+73 +37	+144 +108 +150 +114	+226 +190 +244 +208
400–450 450–500	+40 0	0 −27	+7 −20	+45 +5	+67 +40	+153 +126 +159 +132	+63 0	−68 −131	−20 −60	0 −40	+20 −20	+45 +5	+63 +23	+80 +40	+166 +126 +172 +132	+272 +232 +292 +252

[1] The tolerance classes in **bold** print correspond to row 1 in DIN 7157; their use is preferable.

ISO fits

Basic hole system

cf. DIN ISO 286-2 (1990-11)

Nominal dimension range over–to mm	Limit deviations in µm for tolerance classes[1]													
	for hole	for shafts: Paired with an H8 hole results in a						for hole	for shafts: Paired with an H11 hole results in a					
		clearance fit				interference fit			clearance fit					
	H8	d9	e8	f7	h9	u8[2]	x8[2]	H11	a11	c11	d9	d11	h9	h11
up to 3	+14 0	−20 −45	−14 −28	−6 −16	0 −25	+32 +18	+34 +20	+60 0	−270 −330	−60 −120	−20 −45	−20 −80	0 −25	0 −60
3–6	+18 0	−30 −60	−20 −38	−10 −22	0 −30	+41 +23	+46 +28	+75 0	−270 −345	−70 −145	−30 −60	−30 −105	0 −30	0 −75
6–10	+22 0	−40 −76	−25 −47	−13 −28	0 −36	+50 +28	+56 +34	+90 0	−280 −370	−80 −170	−40 −76	−40 −130	0 −36	0 −90
10–14	+27 0	−50 −93	−32 −59	−16 −34	0 −43	+60 +33	+67 +40	+110 0	−290 −400	−95 −205	−50 −93	−50 −160	0 −43	0 −110
14–18							+72 +45							
18–24	+33 0	−65 −117	−40 −73	−20 −41	0 −52	+74 +41	+87 +54	+130 0	−300 −430	−110 −240	−65 −117	−65 −195	0 −52	0 −130
24–30						+81 +48	+97 +64							
30–40	+39 0	−80 −142	−50 −89	−25 −50	0 −62	+99 +60	+119 +80	+160 0	−310 −470	−120 −280	−80 −142	−80 −240	0 −62	0 −160
40–50						+109 +70	+136 +97		−320 −480	−130 −290				
50–65	+46 0	−100 −174	−60 −106	−30 −60	0 −74	+133 +87	+168 +122	+190 0	−340 −530	−140 −330	−100 −174	−100 −290	0 −74	0 −190
65–80						+148 +102	+192 +146		−360 −550	−150 −340				
80–100	+54 0	−120 −207	−72 −126	−36 −71	0 −87	+178 +124	+232 +178	+220 0	−380 −600	−170 −390	−120 −207	−120 −340	0 −87	0 −220
100–120						+198 +144	+264 +210		−410 −630	−180 −400				
120–140						+233 +170	+311 +248		−460 −710	−200 −450				
140–160	+63 0	−145 −245	−85 −148	−43 −83	0 −100	+253 +190	+343 +280	+250 0	−520 −770	−210 −460	−145 −245	−145 −395	0 −100	0 −250
160–180						+273 +210	+373 +310		−580 −830	−230 −480				
180–200						+308 +236	+422 +350		−660 −950	−240 −530				
200–225	+72 0	−170 −285	−100 −172	−50 −96	0 −115	+330 +258	+457 +385	+290 0	−740 −1030	−260 −550	−170 −285	−170 −460	0 −115	0 −290
225–250						+356 +284	+497 +425		−820 −1110	−280 −570				
250–280	+81 0	−190 −320	−110 −191	−56 −108	0 −130	+396 +315	+556 +475	+320 0	−920 −1240	−300 −620	−190 −320	−190 −510	0 −130	0 −320
280–315						+431 +350	+606 +525		−1050 −1370	−330 −650				
315–355	+89 0	−210 −350	−125 −214	−62 −119	0 −140	+479 +390	+679 +590	+360 0	−1200 −1560	−360 −720	−210 −350	−210 −570	0 −140	0 −360
355–400						+524 +435	+749 +660		−1350 −1710	−400 −760				
400–450	+97 0	−230 −385	−135 −232	−68 −131	0 −155	+587 +490	+837 +740	+400 0	−1500 −1900	−440 −840	−230 −385	−230 −630	0 −155	0 −400
450–500						+637 +540	+917 +820		−1650 −2050	−480 −880				

1) The tolerance classes in **bold** print correspond to row 1 in DIN 7157; their use is preferable.

2) DIN 7157 recommends: nominal dimensions up to 24 mm: H8/x8; nominal dimensions over 24 mm: H8/u8.

ISO fits

Basic shaft system

cf. DIN ISO 286-2 (1990-11)

Nominal dimension range over–to mm	Limit deviations in µm for tolerance classes[1] — for shafts	for holes — Paired with an h5 shaft results in a clearance fit	transition fit		interference fit		for shafts	for holes — Paired with an h6 shaft results in a clearance fit			transition fit				interference fit	
	h5	H6	J6	M6	N6	P6	h6	**F8**	G7	**H7**	J7	K7	M7	N7	R7	S7
up to 3	0 −4	+6 0	+2 −4	−2 −8	−4 −10	−6 −12	0 −6	+20 +6	+12 +2	+10 0	+4 −6	0 −10	−2 −12	−4 −14	−10 −20	−14 −24
3–6	0 −5	+8 0	+5 −3	−1 −9	−5 −13	−9 −17	0 −8	+28 +10	+16 +4	+12 0	+6 −6	+3 −9	0 −12	−4 −16	−11 −23	−15 −27
6–10	0 −6	+9 0	+5 −4	−3 −12	−7 −16	−12 −21	0 −9	+35 +13	+20 +5	+15 0	+8 −7	+5 −10	0 −15	−4 −19	−13 −28	−17 −32
10–18	0 −8	+11 0	+6 −5	−4 −15	−9 −20	−15 −26	0 −11	+43 +16	+24 +6	+18 0	+10 −8	+6 −12	0 −18	−5 −23	−16 −34	−21 −39
18–30	0 −9	+13 0	+8 −5	−4 −17	−11 −24	−18 −31	0 −13	+53 +20	+28 +7	+21 0	+12 −9	+6 −15	0 −21	−7 −28	−20 −41	−27 −48
30–40 40–50	0 −11	+16 0	+10 −6	−4 −20	−12 −28	−21 −37	0 −16	+64 +25	+34 +9	+25 0	+14 −11	+7 −18	0 −25	−8 −33	−25 −50	−34 −59
50–65 65–80	0 −13	+19 0	+13 −6	−5 −24	−14 −33	−26 −45	0 −19	+76 +30	+40 +10	+30 0	+18 −12	+9 −21	0 −30	−9 −39	−30 −60 −32 −62	−42 −72 −48 −78
80–100 100–120	0 −15	+22 0	+16 −6	−6 −28	−16 −38	−30 −52	0 −22	+90 +36	+47 +12	+35 0	+22 −13	+10 −25	0 −35	−10 −45	−38 −73 −41 −76	−58 −93 −66 −101
120–140 140–160 160–180	0 −18	+25 0	+18 −7	−8 −33	−20 −45	−36 −61	0 −25	+106 +43	+54 +14	+40 0	+26 −14	+12 −28	0 −40	−12 −52	−48 −88 −50 −90 −53 −93	−77 −117 −85 −125 −93 −133
180–200 200–225 225–250	0 −20	+29 0	+22 −7	−8 −37	−22 −51	−41 −70	0 −29	+122 +50	+61 +15	+46 0	+30 −16	+13 −33	0 −46	−14 −60	−60 −106 −63 −109 −67 −113	−105 −151 −113 −159 −123 −169
250–280 280–315	0 −23	+32 0	+25 −7	−9 −41	−25 −57	−47 −79	0 −32	+137 +56	+69 +17	+52 0	+36 −16	+16 −36	0 −52	−14 −66	−74 −126 −78 −130	−138 −190 −150 −202
315–355 355–400	0 −25	+36 0	+29 −7	−10 −46	−26 −62	−51 −87	0 −36	+151 +62	+75 +18	+57 0	+39 −18	+17 −40	0 −57	−16 −73	−87 −144 −93 −150	−169 −226 −187 −244
400–450 450–500	0 −27	+40 0	+33 −7	−10 −50	−27 −67	−55 −95	0 −40	+165 +68	+83 +20	+63 0	+43 −20	+18 −45	0 −63	−17 −80	−103 −166 −109 −172	−209 −272 −229 −292

[1] The tolerance classes in **bold** print correspond to row 1 in DIN 7157; their use is preferable.

ISO fits

Basic shaft system cf. DIN ISO 286-2 (1990-11)

35 +0 / −0.062

Limit deviations in µm for tolerance classes[1]

Nominal dimension range over–to mm	for shafts	for holes – Pairing with an h9 shaft results in a								for shafts	for holes – Pairing with an h11 shaft results in a			
	h9	clearance fit					transition fit			h11	clearance fit			
		C11	D10	E9	F8	H8	J9/JS9[2]	N9[3]	P9		A11	C11	D10	H11
bis 3	0	+120	+60	+39	+20	+14	+12,5	−4	−6	0	+330	+120	+60	+60
	−25	+60	+20	+14	+06	0	−12,5	−29	−31	−60	+270	+60	+20	0
3–6	0	+145	+78	+50	+28	+18	+15	0	−12	0	+345	+145	+78	+75
	−30	+70	+30	+20	+10	0	−15	−30	−42	−75	+270	+70	+30	0
6–10	0	+170	+98	+61	+35	+22	+18	0	−15	0	+370	+170	+98	+90
	−36	+80	+40	+25	+13	0	−18	−36	−51	−90	+280	+80	+40	0
10–18	0	+205	+120	+75	+43	+27	+21,5	0	−18	0	+400	+205	+120	+110
	−43	+95	+50	+32	+16	0	−21,5	−43	−61	−110	+290	+95	+50	0
18–30	0	+240	+149	+92	+53	+33	+26	0	−22	0	+430	+240	+149	+130
	−52	+110	+65	+40	+20	0	−26	−52	−74	−130	+300	+110	+65	0
30–40		+280									+470	+280		
	0	+120	+180	+112	+64	+39	+31	0	−26	0	+310	+120	+180	+160
40–50	−62	+290	+80	+50	+25	0	−31	−62	−88	−160	+480	+290	+80	0
		+130									+320	+130		
50–65		+330									+530	+330		
	0	+140	+220	+134	+76	+46	+37	0	−32	0	+340	+140	+220	+190
65–80	−74	+340	+100	+60	+30	0	−37	−74	−106	−190	+550	+340	+100	0
		+150									+360	+150		
80–100		+390									+600	+390		
	0	+170	+260	+159	+90	+54	+43,5	0	−37	0	+380	+170	+260	+220
100–120	−87	+400	+120	+72	+36	0	−43,5	−87	−124	−220	+630	+400	+120	0
		+180									+410	+180		
120–140		+450									+710	+450		
		+200									+460	+200		
140–160	0	+460	+305	+185	+106	+63	+50	0	−43	0	+770	+460	+305	+250
	−100	+210	+145	+85	+43	0	−50	−100	−143	−250	+520	+210	+145	0
160–180		+480									+820	+480		
		+230									+580	+230		
180–200		+530									+950	+530		
		+240									+660	+240		
200–225	0	+550	+355	+215	+122	+72	+57,5	0	−50	0	+1030	+550	+355	+290
	−115	+260	+170	+100	+50	0	−57,5	−115	−165	−290	+740	+260	+170	0
225–250		+570									+1110	+570		
		+280									+820	+280		
250–280		+620									+1240	+620		
	0	+300	+400	+240	+137	+81	+65	0	−56	0	+920	+300	+400	+320
280–315	−130	+650	+190	+110	+56	0	−65	−130	−186	−320	+1370	+650	+190	0
		+330									+1050	+330		
315–355		+720									+1560	+720		
	0	+360	+440	+265	+151	+89	+70	0	−62	0	+1200	+360	+440	+360
355–400	−140	+760	+210	+125	+62	0	−70	−140	−202	−360	+1710	+760	+210	0
		+400									+1350	+400		
400–450		+840									+1900	+840		
	0	+440	+480	+290	+165	+97	+77,5	0	−68	0	+1500	+440	+480	+400
450–500	−155	+880	+230	+135	+68	0	−77,5	−155	−223	−400	+2050	+880	+230	0
		+480									+1650	+480		

[1] The tolerance classes in **bold** print correspond to row 1 in DIN 7157; their use is preferable.
[2] The tolerance zones J9/JS9, J10/JS10 etc. are all identical in size and are symmetrical to the zero line.
[3] Tolerance class N9 may not be used for nominal dimensions ≤ 1mm.

انتخاب نوع انطباق ، انطباقات یاتاقانهای غلتشی

DIN 7157 (1.66) مقایسه با

انتخاب نوع انطباق

کاربرد	ملاحظات	نوبت میله [a]	نوبت سوراخ [a]
لقی			
تأسیسات نوار نقاله ، ماشینهای کشاورزی	اجزاء گردان با لقی زیاد می گردند.	D10/h9	H8/d9
یاتاقان با روغنکاری حلقه ای ، محور گردان	اجزاء گردان با لقی کافی می گردند .	E9/ h9	H8/e8
کشوئیهای راهنما	اجزاء گردان با لقی قابل توجهی می گردند.	F8/ h6	H7/ f7
یاتاقان محور سنگ ، چرخدنده های کشوئی ، محور ـ دستگاه تقسیم	اجزاء گردان بدون لقی قابل توجهی می گردند.	G7/h6	H7/g6
مرغک در دستگاه مرغک ، بوش میل راهنما	این اجزاء به صورت سرشی در یکدیگر عمل کرده و با دست قابل حرکت هستند .	H7/ h6	H7/ h6
لقی یا پرسی			
فلکه های تسمه ، چرخدنده ها ، توپیها و محور ها با اتصال خارفنری و گوه ای	اجزاء با ضربه های آرام و یا با دست جا به جا می شوند.		H7/j6
بوش یاتاقان ، گژنپین، میل راهنما	اجزاء با نیروی کم جا به جا می شوند .		H7/n6
پرسی			
بوش یاتاقان در پوسته	این اجزاء رامی توان با را صرف نیروی زیاد جازد .		H7/ r6
تاج چرخدنده ، حلقه های انقباظی	این اجزاء را می توان فقط با صرف نیروی زیاد ، و یا با استفاده از انبساط و انقباض جازد.		H7/s6
چرخ روی محور ، کوپلینگ روی محور	این اجزاء فقط با انبساط و یا انقباض در یکدیگر جازده می شوند .		H8/u8

a موارد ذکر شدهٔ پر رنگ لرجحیت دارد .

		Clearance fits		
0 H8 d9	H8/d9	**Loose running fit** Clearance allows for loose fit of mating parts. (i.e. spacer sleeves on shafts)	**D10/h9**	D10 0 h9
0 H8 e8	H8/e8	**Free running fit (Medium running fit):** Sufficient clearance is allowed for ease of assembly. (i.e. collar on shaft)	**E9/h9**	E9 0 h9
0 H8 f7	**H8/f7**	**Close running fit:** Clearance allows for parts to be easily assembled by hand while maintaining location accuracy. (i.e. plain bearing of shaft)	**F8/h9**	F8 0 h9
0 H7 f7	**H7/f7**	**Sliding fit – free:** Clearance allows accurate location and free movement, including turning. (i.e. piston valves in cylinders)	**F8/h6**	F8 0 h6
0 H7 g6	H7/g6	**Sliding fit – constrained:** Clearance allows better locational accuracy while still allowing sliding or turning movement. (i.e. transmission gear on shaft)	G7/h6	G7 0 h6
0 H8 h9	**H8/h9**	**Minimal clearance fit:** Allows locational accuracy and hand force assembly without being a snug fit. (i.e. spacer sleeves)	**H8/h9**	0 H8 h9
0 H7 h6	**H7/h6**	**Locational clearance fit:** Allows snug fit of stationary parts that may be assembled by hand force. (i.e. punch in punch holder)	**H7/h6**	0 H7 h6
		Transition fits		
0 H7 j6	H7/j6	**Locational transition fit – clearance:** For accurate location allowing more clearance than interference. (i.e. gears on shafts)	not specified	
n6 0 H7	**H7/n6**	**Locational transition fit – interference:** For accurate location where interference is permissible. (i.e. drill bushing in jigs)	not specified	
		Interference fits		
r6 0 H7	**H7/r6**	**Locational interference fit:** For rigidity and alignment/accurate location without special bore requirements. (i.e. bushings in housings)	not specified	
s6 0 H7	H7/s6	**Medium drive fit:** For ordinary steel parts or shrink fits of light sections. Tightest fit possible for cast iron. (i.e. plain bearing bushings)	not specified	
u8 0 H8	**H8/u8**	**Force fit:** For parts fitting that can withstand high mechanical pressing force or shrink fitting. (i.e. wheel on axle)	not specified	
x8 0 H8	**H8/x8**	**Extreme force fit:** For parts that can only be assembled by stretching or shrinking. (i.e. turbine blade on shaft)	not specified	

DIN 5425 T1 (11.84) مقایسه با					تلرانسهای مورد نیاز برای مونتاژ یاتاقانها (غلتشی)
					یاتاقان محوری
			روی محور		روی پوسته یاتاقان
[illegible]	نوع یاتاقان	نوع بار	تلرانس محور	نوع بار	تلرانس پوسته
[illegible]	یاتاقانهای محوری : ساچمه ای مایل ، بشکه ای خود تنظیم ، مخروطی	محیطی (گسترده)	j k m	متمرکز	H J
		متمرکز	j	محیطی (گسترده)	K M
	یاتاقانهای محوری : ساچمه ای ، استوانه ای و بشکه ای	–	h j k	–	H G E

Thrust bearing

Load type	Bearing construction	Shaft washer (shaft): Load case	Shaft washer (shaft): Fundamental deviat. for shafts[1]	Housing plate (housing): Load case	Housing plate (housing): Fundamental deviations for housing[1]
Combined radial/axial load	angular contact ball bearing spherical roller bearing tapered roller bearing	circumfer. load	j, k, m	point load	H, J
		point load	j	circumfer. load	K, M
Pure axial load	ball bearing roller bearing	–	h, j, k	–	H, G, E

انطباقات یاتاقانهای غلتشی(بلبیرینگها) و تلرانسهای عمومی

DIN 5425 T1 (11.84) مقایسه با									تلرانس مونتاژ یاتاقانهای غلتشی
									یاتاقان شعاعی
حلقهٔ داخلی (محور)					حلقهٔ بیرونی (پوسته)				
نوع بار	انطباق	مقدار بار	تلرانس یاتاقان ساچمه ای ،استوانه ای ، بشکه ای		نوع بار	انطباق	مقدار بار	تلرانس یاتاقان استوانه ای ، بشکه ای	تلرانس یاتاقان ساچمه ای
محیطی (گسترده)	تکیه گاه ثابت لازم است	کم	h k	k m	متمرکز	تکیه گاه آزاد مجاز است	به اندازهٔ دلخواه بزرگ	J H G F	
		متوسط	j k m	k m n p					
		زیاد	m n	n p r					
متمرکز	تکیه گاه آزاد مجاز است	به اندازهٔ دلخواه بزرگ	j h g f		محیطی	تکیه گاه ثابت لازم است	کم	J	K
							متوسط	K M	M N
							زیاد	–	N P

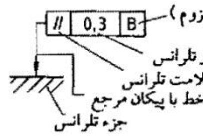
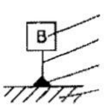
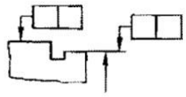
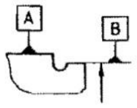
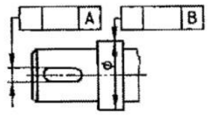
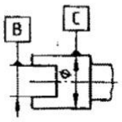
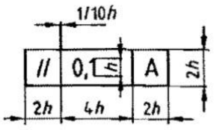
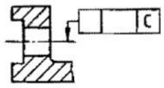
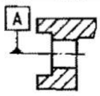
تلرانس عمومی (قدیمی، منسوخ)

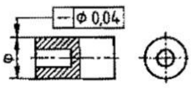
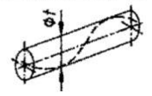
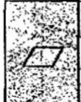
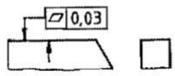
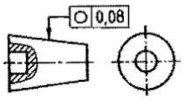
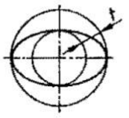
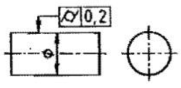
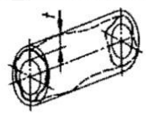
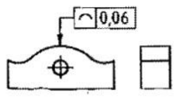
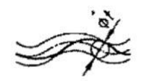
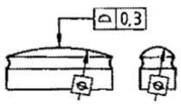
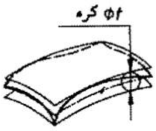
DIN 7168 T1(5.81) مقایسه با									تلرانس طول
درجهٔ تلرانس	از 0,5 تا 3	از 3 تا 6	از 6 تا 30	از 30 تا 120	از 120 تا 400	از 400 تا 1000	از 1000 تا 2000	از 2000 تا 4000	از 4000 تا 8000
f (ظریف)	± 0, 05	± 0, 05	± 0,1	± 0,15	± 0,2	± 0,3	± 0,5	± 0,8	-
m (متوسط)	± 0,1	± 0,1	± 0,2	± 0,3	± 0,5	± 0,8	± 1,2	± 2	± 3
g (خشن)	± 0,15	± 0,2	± 0,5	± 0,8	± 1,2	± 2	± 3	± 4	± 5
sg (خیلی خشن)	-	± 0,5	± 1	± 1,5	± 2	± 3	± 4	± 6	± 8

DIN 7168 T1(5.81) مقایسه با										تلرانس گردیها ، پخها و زوایا
درجهٔ تلرانس	شعاع گردیهاوپخها محدودهٔ تلرانس به mm برای محدودهٔ اندازه نامی					اندازه زوایا محدوده تلرانس به درجه یا دقیقه برای محدودهٔ اندازه نامی (ضلع کوتاهتر)				
	از 0,5 تا 3	از 3 تا 6	از 6 تا 30	از 30 تا 120	از 120 تا 400	تا 10	از 10 تا 50	از 50 تا 120	از 120 تا 400	بالای 400
f (ظریف) m (متوسط)	± 0,2	± 0,5	± 1	± 2	± 4	± 1°	± 30′	± 20′	± 10′	± 5′
g (خشن)	± 0,2	± 1	± 2	± 4	± 8	± 1° 30′	± 50′	± 25′	± 15′	± 10′
sg (خیلی خشن)						± 3°	± 2°	± 1°	± 30′	± 20′

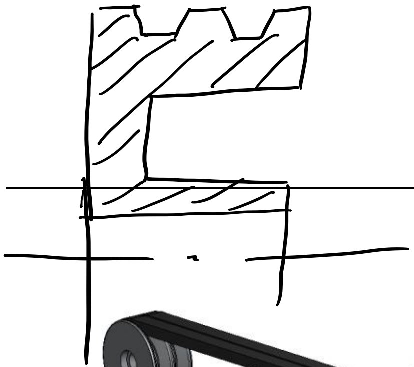
DIN 7168 T2 (7.86) مقایسه با									تلرانسهای عمومی هندسی و وضعی
درجهٔ تلرانس	محدوده تلرانسهای عمومی به mm برای راستی و تختی تا 6	از 6 تا 30	از 30 تا 120	از 120 تا 400	از 400 تا 1000	از 1000 تا 2000	از 2000 تا 4000	تلرانس تقارن	تلرانس لنگی طولی وعرضی
R	0,004	0, 01	0,02	0,04	0,07	0,1	-	0,3	0,1
S	0,008	0,02	0,04	0,08	0,15	0,2	0,3	0,5	0,2
T	0,025	0,06	0,12	0,25	0,4	0,6	0,9	1	0,5
U	0,1	0,25	0,5	1	1,5	2,5	3,5	2	1

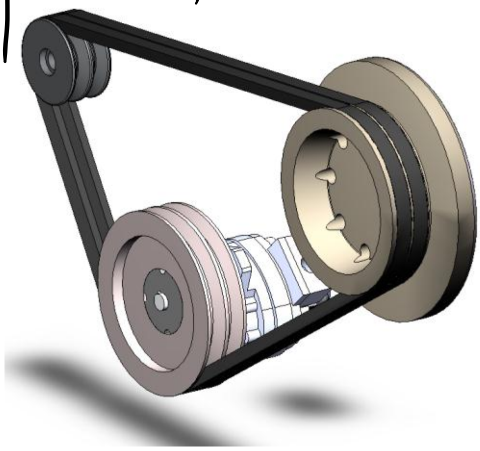
تلرانسهای هندسی و وضعی

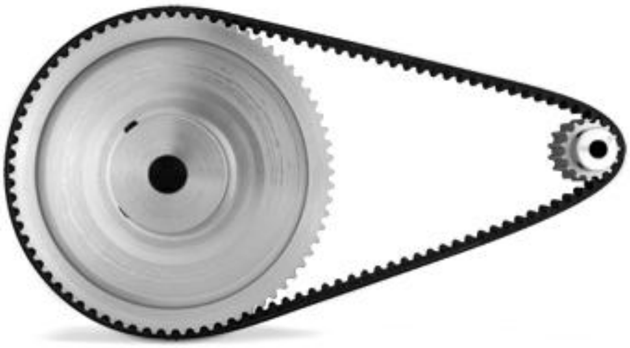
نحوه بیان در نقشه کشی		مقایسه با DIN ISO 1101(3.85)
اجزاء مورد نظر	**مرجع**	**اصطلاحات عمومی**
		هنگامی از تلرانسهای هندسی و وضعی در نقشه ها استفاده می شود که بنا به دلایل ساخت، عملکرد یا قابلیت تعویض شدن قطعهٔ کار، به آن نیاز باشد.
تلرانس بر اساس سطح و خط مرجع 	مرجع یک سطح و یا یک خط است. 	
تلرانس بر اساس سطح وسط شیار و محور قطر مرجع 	مرجع، سطح وسط شیار و محور قطر است. 	ابعاد چار چوب تلرانس 
تلرانس بر اساس محور یا خط مرکزی مشترک 	مرجع، محور یا خط مرکزی مشترک است. 	ارتفاع حروف h

انواع تلرانس	علائم و معانی		علائم در نقشهٔ فنی	توضیحات	منطقهٔ تلرانس
تلرانس هندسی		راستی		محور تلرانس استوانه (استوانهٔ بیرون)؟ باید در داخل استوانه ای به قطر t = 0,04 mm قرار گیرد.	
		تختی		سطح تلرانسی باید بین دو سطح موازی که فاصلهٔ آنها از یکدیگر t = 0,03 mm است قرار گیرد.	
		گردی		خط پیرامون درهرسطح برش عمود بر محور باید بین دو دایرهٔ هم مرکزکه فاصله آنهااز یکدیگر t = 0,08 mm می باشد، قرار گیرد.	
		استوانه ای		سطح پیرامون تلرانسی استوانه باید بین دو استوانه هم-محور که به فاصلهٔ t = 0,2 mm از یکدیگر می-باشند، قرار گیرد.	
		فرم خطی		پروفیل تلرانسی باید بین دو خط پوش که فاصلهٔ آنها توسط دوایری به قطر t = 0,06 mm محدود شده است، قرار گیرد . مرکز این دایره ها برروی خط ایده-آل قرار می گیرد.	
		فرم سطحی		سطح تلرانسی بایستی بین دو سطح پوش که فاصلهٔ آنها توسط کره هائی به قطر t = 0,3 mm از یکدیگر محدود شده است ، قرار گیرد. مرکز کره ها برروی سطح ایده آل هندسی قرار دارد.	

۵-تسمه



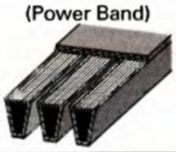
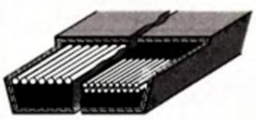




بخش اول؛ بر مبنای واحدهای متریك

V-belts, Positive drive belts

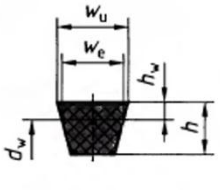
Design types

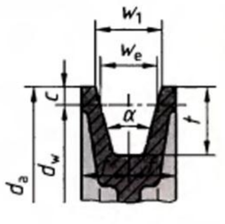
Designation	Standard for the belts	h[1] in mm	L[2] in mm	Standard for pulleys	Speed range v_{max} in m/s	Power range P'_{max} in kW[3]	Properties, application
Classic V-belts 	DIN 2215, ISO 4184	4–25	185–19000	DIN 2217, ISO 4183	30	65	For higher maximum tensile strengths, reliable tractive power; construction equipment, variable drives for the mining industry, agricultural machinery, conveyors, general machine construction
Narrow V-belts 	DIN 7753, ISO 4184	8–18	630–12500	DIN 2211, ISO 4183	40	70	Good power transmission, twice the power with the same width as classic V-belts; gearbox manufacturing, machine tools, HVAC
Cogged V-belts 	DIN 2215, DIN 7753	4–25	800–3150	DIN 2211, DIN 2217	50	70	Low elongation, small pulley diameter, high temperature resistance from −30°C to +80°C; automotive alternator drives, transmission design, pumps, HVAC
Joined V-belts (Power Band) 		10–26	1250–15000	DIN 2211, DIN 2217	30	65	Insensitive to vibration or impact, no twisting of single belts in the pulleys, absolutely uniform force distribution, high tensile strength, for long distances between axles; paper machines
V-ribbed belts (ribbed belts) 	DIN 7867	3–17	600–15000	DIN 7867	60	20	Large transmission ratios possible, low vibration running behavior; automotive alternator drives, compressor drives in HVAC, small machines
Wide V-belts 	DIN 7719	6–18	468–2500	DIN 7719	30	85	Excellent transverse strength, very high tensile strength, flexible; speed control gears, machine tools, textile machines, printing machines, agricultural machinery
Double V-belts (Hexagonal belts) 	DIN 7722, ISO 5289	10–25	2000–6900	DIN 2217	30	20	Good power transmission for drives with several pulleys and alternating direction of rotation, 10% less efficiency than classic V-belts; agricultural machinery, textile machines, general machine building
Positive drive belts 	DIN 7721, DIN ISO 5296	0.7–5.0	100–3620	DIN ISO 5294	40–80	0.5–900	Efficiency $\eta_{max} \geq 0.98$, synchronous running, low prestress forces, therefore lower bearing load; precision machine drives, office machine drives, automotive industry, CNC spindle drives

[1] Belt height (pages 254, 255) [2] Belt length [3] Transmittable power per belt

Narrow V-belts

Narrow V-belts DIN 7753-1 (1988-01)	Narrow V-belt pulley DIN 2211-1 (1984-03)

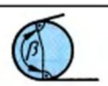




Effective diameter $d_e = d_a - 2 \cdot c$

⇒ **Narrow V-belt DIN 7753 – XPZ 710:** Narrow V-belt, cogged profile, reference length 710 mm

	Designations	Narrow V-belts, V-belt pulleys			
	Belt profile (ISO designation codes)	SPZ	SPA	SPB	SPC
w_u	upper belt width	9.7	12.7	16.3	22
w_e	effective width	8.5	11	14	19
h	belt height	8	10	13	18
h_w	distance	2	2.8	3.5	4.8
d_{min}	minimum allowable effective ∅	63	90	140	224
w_1	upper groove width	9.7	12.7	16.3	22
c	distance from effective ∅ to outer ∅	2	2.8	3.5	4.8
t	minimum allowable groove depth	11	13.8	17.5	23.8
e	groove spacing for multi-groove pulleys	12	15	19	25.5
f	groove spacing from outer edge	8	10	12.5	17
α	34° for effective ∅ up to	80	118	190	315
	38° for effective ∅ over	80	118	190	315



Angle factor c_1	1	1.02	1.05	1.08	1.12	1.16	1.22	1.28	1.37	1.47
Wrap angle β	180°	170°	160°	150°	140°	130°	120°	110°	100°	90°

Service factor c_2

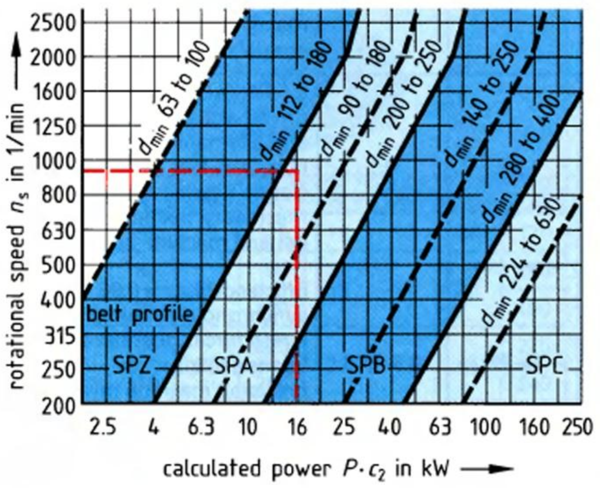
Daily operating time in hours: up to 10	from 10 to 16	over 16	Driven machines (examples)
1.0	1.1	1.2	Centrifugal pumps, fans, conveyor belts for light material
1.1	1.2	1.3	Machine tools, presses, sheet metal shearers, printing machines
1.2	1.3	1.4	Grinding gears, piston pumps, textile and paper machines
1.3	1.4	1.5	Stone crushers, mixers, winches, cranes, excavators

Efficiency values for narrow V-belts

cf. DIN 7753-2 (1976-04)

Belt profile	SPZ			SPA			SPB			SPC		
smaller pulley d_{min}	63	100	180	90	160	250	140	250	400	224	400	630
smaller pulley n_s	Power rating P_{rated} in kW per belt											
400	0.35	0.79	1.71	0.75	2.04	3.62	1.92	4.86	8.64	5.19	12.56	21.42
700	0.54	1.28	2.81	1.17	3.30	5.88	3.02	7.84	13.82	8.13	19.79	32.37
950	0.68	1.66	3.65	1.48	4.27	7.60	3.83	10.04	17.39	10.19	24.52	37.37
1450	0.93	2.36	5.19	2.02	6.01	10.53	5.19	13.66	22.02	13.22	29.46	31.74
2000	1.17	3.05	6.63	2.49	7.60	12.85	6.31	16.19	22.07	14.58	25.81	–
2800	1.45	3.90	8.20	3.00	9.24	14.13	7.15	16.44	9.37	11.89	–	–

Profile selection for narrow V-belts



P	power to be transmitted
P_{rated}	power rating per belt
N	number of belts
c_1	angle factor
c_2	service factor

Number of belts

$$N = \frac{P \cdot c_1 \cdot c_2}{P_{rated}}$$

Example:

Transmission parameters $P = 12$ kW with $c_1 = 1.12$; $c_2 = 1.4$; $d_{min} = 160$ mm, $n_s = 950$ 1/min; $\beta_s = ?$, $N = ?$

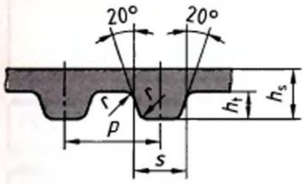
1. $P \cdot c_2 = 12 \text{ kW} \cdot 1.4 = 16.8$ kW
2. From the diagram $n_s = 950$ 1/min and $P \cdot c_2 = 16.8$ kW → profile **SPA**
3. $P_{rated} = 4.27$ kW from the table
4. $N = \frac{P \cdot c_1 \cdot c_2}{P_{rated}} = \frac{12 \text{ kW} \cdot 1.12 \cdot 1.4}{4.27 \text{ kW}} = 4.4$
5. Selected: N = **5 belts**

Positive drive belts

Positive drive belts (timing belts)

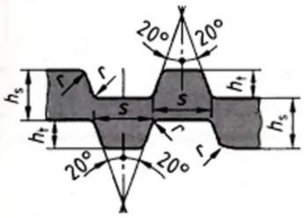
cf. DIN 7721-1 (1989-06)

Single-sided



Tooth spacing Code	p	Tooth size s	h_t	r	Nominal thickness h_s	Positive drive belt width w			
T2.5	2.5	1.5	0.7	0.2	1.3	–	4	6	10
T5	5	2.7	1.2	0.4	2.2	6	10	16	25
T10	10	5.3	2.5	0.6	4.5	16	25	32	50

Double-sided



Effective length[1]	No. of teeth for T2.5	No. of teeth for T5	Effective length[1]	No. of teeth for T5	No. of teeth for T10	Effective length[1]	No. of teeth for T10
120	48	–	530	–	53	1010	101
150	–	30	560	112	56	1080	108
160	64	–	610	122	61	1150	115
200	80	40	630	126	63	1210	121
245	98	49	660	–	66	1250	125
270	–	54	700	–	70	1320	132
285	114	–	720	144	72	1390	139
305	–	61	780	156	78	1460	146
330	132	66	840	168	84	1560	156
390	–	78	880	–	88	1610	161
420	168	84	900	180	–	1780	178
455	–	91	920	184	92	1880	188
480	192	96	960	–	96	1960	196
500	200	100	990	198	–	2250	225

⇒ **Belt DIN 7721 – 6 T2.5 x 480:** w = 6 mm, spacing p = 2.5 mm, effective length = 480 mm, single-sided

Non-standardized tooth forms

HT profile LAHN profile

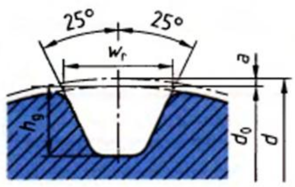
The code letter D is added for double-sided positive drive belts.

[1] Effective lengths from 100–3620 mm, in custom-made products up to 25000 mm

Timing belt pulleys

cf. DIN 7721-2 (1989-06)

Pulley groove dimensions



Effective diameter

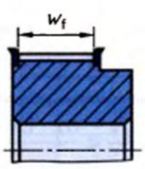
$$d = d_0 + 2 \cdot a$$

[1] Form SE for ≤ 20 grooves
[2] Form N for > 20 grooves

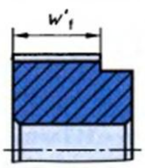
Pulley groove	Pulley outer Ø d_0 for T2.5	T5	T10	Pulley groove	Pulley outer Ø d_0 for T2.5	T5	T10	Pulley groove	Pulley outer Ø d_0 for T2.5	T5	T10
10	7.4	15.0	–	17	13.0	26.2	52.2	32	24.9	50.1	100.0
11	8.2	16.6	–	18	13.8	27.8	55.4	36	28.1	56.4	112.7
12	9.0	18.2	36.3	19	14.6	29.4	58.6	40	31.3	62.8	125.4
13	9.8	19.8	39.5	20	15.4	31.0	61.8	48	37.7	75.5	150.9
14	10.6	21.4	42.7	22	17.0	34.1	68.2	60	47.2	94.6	189.1
15	11.4	23.0	45.9	25	19.3	38.9	77.7	72	56.8	113.7	227.3
16	12.2	24.6	49.1	28	21.7	43.7	87.2	84	66.3	132.9	265.5

Code	Pulley groove dimensions: Groove width w_r Form SE[1]	Groove width w_r Form N[2]	Groove height h_g Form SE[1]	Groove height h_g Form N[2]	$2a$
T2.5	1.75	1.83	0.75	1	0.6
T5	2.96	3.32	1.25	1.95	1
T10	6.02	6.57	2.6	3.4	2

Pully dimensions



with pulley flange

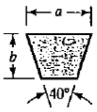


without pulley flange

Letter symbols	Belt width w	Pulley width with flange w_f	Pulley width without flange w'_f
T2.5	4	5.5	8
	6	7.5	10
	10	11.5	14
T5	6	7.5	10
	10	11.5	14
	16	17.5	20
	25	26.5	29
T10	16	18	21
	25	27	30
	32	34	37
	50	52	55

Table 17-9

Standard V-Belt Sections



Belt Section	Width a, mm	Thickness b, mm	Minimum Sheave Diameter, mm	kW Range, One or More Belts
A	12	8.5	75	0.2–7.5
B	16	11	135	0.7–18.5
C	22	13	230	11–75
D	30	19	325	37–186
E	38	25	540	75 and up

Table 17-10

Inside Circumferences of Standard V Belts

Section	Circumference, mm
A	650, 775, 825, 875, 950, 1050, 1150, 1200, 1275, 1325, 1375, 1425, 1500, 1550, 1600, 1650, 1700, 1775, 1875, 1950, 2000, 2125, 2250, 2400, 2625, 2800, 3000, 3200
B	875, 950, 1050, 1150, 1200, 1275, 1325, 1375, 1425, 1500, 1550, 1600, 1650, 1700, 1775, 1875, 1950, 2000, 2125, 2250, 2400, 2625, 2800, 3000, 3200, 3275, 3400, 3450, 3950, 4325, 4500, 4875, 5250, 6000, 6750, 7500
C	1275, 1500, 1700, 1875, 2025, 2125, 2250, 2400, 2625, 2800, 3000, 3200, 3400, 3600, 3950, 4050, 4350, 4500, 4875, 5250, 6000, 6750, 7500, 8250, 9000, 9750, 10 500
D	3000, 3200, 3600, 3950, 4050, 4350, 4500, 4875, 5250, 6000, 6750, 7500, 8250, 9000, 9750, 10 500, 12 000, 13 500, 15 000, 16 500
E	4500, 4875, 5250, 6000, 6750, 7500, 8250, 9000, 9750, 10 500, 12 000, 13 500, 15 000, 16 500

Table 17-11

Length Conversion Dimensions (Add the Listed Quantity to the Inside Circumference to Obtain the Pitch Length in mm)

Belt section	A	B	C	D	E
Quantity to be added	32	45	72	82	112

Table 17–12

Power (kW) Ratings of Standard V Belts

Belt Section	Sheave Pitch Diameter, mm	Belt Speed, m/s 5	10	15	20	25
A	65	0.35	0.46	0.40	0.11	
	75	0.49	0.75	0.84	0.69	0.28
	85	0.60	0.98	1.17	1.64	0.84
	95	0.69	1.16	1.43	1.49	1.28
	105	0.77	1.30	1.64	1.78	1.63
	115	0.83	1.41	1.82	2.01	1.93
	125 and up	0.87	1.51	1.97	2.21	2.16
B	105	0.80	1.18	1.25	0.94	0.16
	115	0.95	1.48	1.71	1.55	0.92
	125	1.07	1.74	2.09	2.06	1.57
	135	1.19	1.95	2.42	2.49	2.10
	145	1.28	2.14	2.69	2.87	2.57
	155	1.36	2.31	2.94	3.19	2.98
	165	1.43	2.45	3.16	3.48	3.34
	175 and up	1.50	2.58	3.35	3.74	3.66
C	150	1.37	1.98	2.03	1.40	
	175	1.85	2.94	3.46	3.31	2.33
	200	2.21	3.66	4.54	4.74	4.12
	225	2.49	4.21	5.38	5.86	5.51
	250	2.72	4.66	6.05	7.16	6.63
	275	2.89	5.03	6.59	7.46	7.53
	300 and up	3.05	5.33	7.06	8.13	8.28
D	250	3.09	4.57	4.89	3.80	1.01
	275	3.73	5.84	6.80	6.34	4.19
	300	4.26	6.91	8.36	8.50	6.85
	325	4.71	7.83	9.70	10.30	9.10
	350	5.09	8.58	10.89	11.79	11.04
	375	5.42	9.25	11.86	13.13	12.68
	400	5.71	9.85	12.76	14.32	14.17
	425 and up	5.98	10.37	13.50	15.37	15.44
E	400	6.48	10.44	13.06	13.50	11.41
	450	7.40	12.46	15.82	17.16	16.04
	500	8.13	13.95	18.05	20.07	19.69
	550	8.73	15.14	19.84	22.53	22.75
	600	9.25	16.11	21.34	24.54	25.22
	650	9.70	17.01	22.60	26.19	27.38
	700 and up	10.00	17.68	23.72	27.68	29.17

Table 17–13

Angle of Contact Correction Factor K_1 for VV* and V-Flat Drives

$\frac{D-d}{C}$	θ, deg	K_1 VV	V Flat
0.00	180	1.00	0.75
0.10	174.3	0.99	0.76
0.20	166.5	0.97	0.78
0.30	162.7	0.96	0.79
0.40	156.9	0.94	0.80
0.50	151.0	0.93	0.81
0.60	145.1	0.91	0.83
0.70	139.0	0.89	0.84
0.80	132.8	0.87	0.85
0.90	126.5	0.85	0.85
1.00	120.0	0.82	0.82
1.10	113.3	0.80	0.80
1.20	106.3	0.77	0.77
1.30	98.9	0.73	0.73
1.40	91.1	0.70	0.70
1.50	82.8	0.65	0.65

*A curvefit for the VV column in terms of θ is
$K_1 = 0.143\,543 + 0.007\,46\,8\,\theta - 0.000\,015\,052\,\theta^2$
in the range $90^\circ \le \theta \le 180^\circ$.

Table 17–14

Belt-Length Correction Factor K_2*

Length Factor	A Belts	B Belts	C Belts	D Belts	E Belts
	Nominal Belt Length, m				
0.85	Up to 0.88	Up to 1.15	Up to 1.88	Up to 3.2	
0.90	0.95–1.15	1.2–1.5	2.03–2.4	3.6–4.05	Up to 4.88
0.95	1.2–1.38	1.55–1.88	2.63–3.0	4.33–5.25	5.25–6.0
1.00	1.5–1.88	1.95–2.43	3.2–3.95	6.0	6.75–7.5
1.05	1.95–2.25	2.63–3.0	4.05–4.88	6.75–8.25	8.25–9.75
1.10	2.4–2.8	3.2–3.6	5.25–6.0	9.0–10.5	10.5–12.0
1.15	3.0 and up	3.95–4.5	6.75–7.5	12.0	13.5–15.0
1.20		4.88 and up	8.25 and up	13.5 and up	16.5

*Multiply the rated power per belt by this factor to obtain the corrected power.

Table 17–15

Suggested Service Factors K_S for V-Belt Drives

Driven Machinery	Source of Power: Normal Torque Characteristic	Source of Power: High or Nonuniform Torque
Uniform	1.0 to 1.2	1.1 to 1.3
Light shock	1.1 to 1.3	1.2 to 1.4
Medium shock	1.2 to 1.4	1.4 to 1.6
Heavy shock	1.3 to 1.5	1.5 to 1.8

Table 17–16

Some V-Belt Parameters*

Belt Section	K_b	K_c
A	25	0.561
B	65.0	0.965
C	180	1.716
D	642	3.498
E	1226	5.041
3V	26	0.425
5V	124	1.217
8V	546	3.288

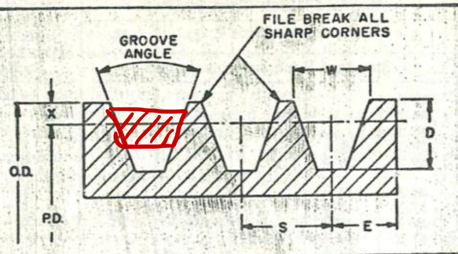
Table 17–17

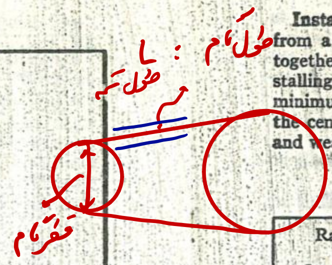
Durability Parameters for Some V-Belt Sections

Source: M. E. Spotts, *Design of Machine Elements*, 6th ed. Prentice Hall, Englewood Cliffs, N.J., 1985.

Belt Section	10^8 to 10^9 Force Peaks K	10^8 to 10^9 Force Peaks b	10^9 to 10^{10} Force Peaks K	10^9 to 10^{10} Force Peaks b	Minimum Sheave Diameter, mm
A	2999	11.089			75
B	5309	10.926			125
C	9069	11.173			215
D	18 726	11.105			325
E	26 791	11.100			540
3V	3240	12.464	4726	10.153	66
5V	7360	12.593	10 653	10.283	177
8V	16 189	12.629	23 376	10.319	312

Table 9. Groove Dimensions and Tolerances for Multiple V-belt Sheaves





Belt	Pitch Diameter: Minimum Recommended	Pitch Diameter: Range	Groove Angle	Standard Groove Dimensions: W	D	X	S[1]	E	Deep Groove Dimensions: W	D	X	S[1]	E
			±½°	(2)	±.031	....	±.031	(3)	(2)	±.031	....	±.031	(3)
A	3.0	2.6 to 5.4 Over 5.4	34° 38°	.494 .504	.490	.125	5/8	3/8	.589 .611	.645	.280	3/4	7/16
B	5.4	4.6 to 7.0 Over 7.0	34° 38°	.637 .650	.580	.175	3/4	1/2	.747 .774	.760	.355	7/8	9/16
C	9.0	7.0 to 7.99 8.0 to 12.0 Over 12.0	34° 36° 38°	.879 .887 .895	.780	.200	1	11/16	1.066 1.085 1.105	1.085	.505	1 1/4	13/16
D	13.0	12.0 to 12.99 13.0 to 17.0 Over 17.0	34° 36° 38°	1.259 1.271 1.283	1.050	.300	1 7/16	7/8	1.513 1.541 1.569	1.465	.715	1 3/4	1 1/16
E	21.0	18.0 to 24.0 Over 24.0	36° 38°	1.527 1.542	1.300	.400	1 3/4	1 1/8	1.816 1.849	1.745	.845	2 1/16	1 5/16

All dimensions in inches except groove angles are in degrees.

[1] Summation of the deviations from *S* for all grooves in any one sheave shall not exceed ±0.063 inch.

[2] Tolerances for *W*: for A and B belts are ±.005 inch; for C and D belts, ±.007 inch; and for E belt, ±.010 inch.

[3] Tolerances for *E*: for A belts are, +.070, −.000 inch; for B and C belts, +.150, −.000 inch; and for D and E belts, +.250, −.000 inch.

Outside Diameter Tolerances: Under 12 inches, ±.020 inch; 12.0 up to 24.0 inches, ±.040 inch; 24 up to 58 inches, .060 inch; 58.0 up to 72.0 inches, ±.120 inch; and for 72 inches and above, ±.250 inch.

Outside Diameter Eccentricity: For 10.0-inch pitch diameter and under, .010 inch. Add .0005 inch for each additional inch of pitch diameter up to and including 60.0-inch pitch diameter. Add .001 inch for each additional inch of pitch diameter above 60 inches.

Side Wobble and Runout: .001 inch per inch of pitch diameter up to 20 inches. Add .0005 inch for each additional inch of pitch diameter up to and including 60.0 inches. Add .001 inch for each additional inch of pitch diameter above 60.0 inches.

For standard key and keyway dimensions, see pages 872 and 873.

Installation and Take-up Allowance.—After calculating a center distance from a standard pitch length, provision should be made for moving the centers together by an amount, as shown by the minus values in Table 10, to permit installing the belts over the sheaves without injury. Also shown in Table 10 is the minimum allowance above the standard center distance (plus values) for which the centers should be adjustable to take up any slack in the belts due to stretch and wear.

Table 10. Minimum Center Distance Allowances for Installation and Take-up of Multiple V-belts

Range of Standard Lengths	Minimum Allowance Below (−) and Above (+) Standard Center Distance: A	B	C	D	E
26 to 38	−3/4, +1	−1, +1	....	....	....
38 to 60	−3/4, +1 1/2	−1, +1 1/2	−1 1/2, +1 1/2	....	....
60 to 90	−3/4, +2	−1 1/4, +2	−1 1/2, +2	....	....
90 to 120	−1, +2 1/2	−1 1/4, +2 1/2	−1 1/2, +2 1/2	....	....
120 to 158	−1, +3	−1 1/4, +3	−1 1/2, +3	−2, +3	....
158 to 195	....	−1 1/4, +3 1/2	−2, +3 1/2	−2, +3 1/2	−2 1/2, +3 1/2
195 to 240	....	−1 1/2, +4	−2, +4	−2, +4	−2 1/2, +4
240 to 270	....	....	−2, +4 1/2	−2 1/2, +4 1/2	−2 1/2, +4 1/2
270 to 330	....	....	−2, +5	−2 1/2, +5	−3, +5
330 to 420	....	....	−2, +6	−2 1/2, +6	−3, +6
420 and over	....	....	....	−3, *	−3 1/2, *

All dimensions in inches.

* For this belt size and lengths, 1.5 per cent of belt length above standard center distance for stretch and wear.

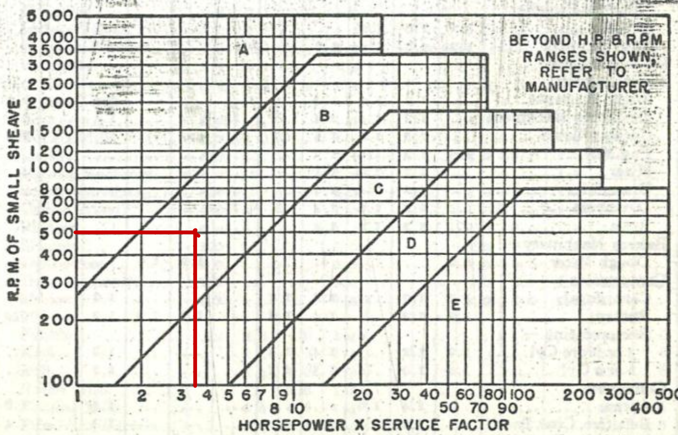


Chart for Selection of V-Belt for Given Drive

بخش دوم: بر مبنای واحدهای اینچی

Selection of Multiple V-Belts. — The chart on page 955 which appears in Engineering Standards for Multiple V-Belt Drives enables a V-belt of appropriate cross-section to be selected for a given drive if the revolutions per minute of the small sheave, the transmitted horsepower of the driving unit, and the service factor are known. The selection procedure is as follows:

1. Multiply the horsepower to be transmitted by the drive by the proper service factor (Table 11) to obtain the "design horsepower."

2. Enter the chart at the rpm of the small sheave and proceed horizontally to a point in vertical line with the design horsepower.

3. If this point falls in the area marked A, then an A size belt is required or,

Table 11. Service Factors for Multiple V-belt Applications

Applications	Electric Motors										
	A.C.								D.C.		
	Squirrel Cage				Synchronous		Single Phase				
	Normal Torque Line Start	Normal Torque Compensator Start	High Torque	Wound Rotor (Slip Ring)	Normal Torque	High Torque	Repulsion and Split-Phase	Capacitor	Shunt Wound	Compound Wound	Line Shaft and Clutch Shifting
	Service Factors										
Agitators —											
Paddle-Propeller											
Liquid	1.0	1.0	1.2	...	...	...	...	...	...	...	...
Semi-Liquid	1.2	1.0	1.4	1.2	...	...	...	...	...	...	...
Brick and Clay Machinery											
Auger Machines	...	1.2	1.4	1.4	...	...	...	...	1.4	...	2.0
De-Airing Machines	...	1.2	1.4	1.4	...	...	...	...	1.4	...	2.0
Cutting Table	...	1.2	1.4	1.4	...	...	...	...	...	...	2.0
Pug Mill	1.5	1.3	1.8	1.5	...	...	...	...	...	...	...
Mixer	...	1.2	1.6	1.4	...	...	...	...	...	...	...
Granulator	...	1.2	1.4	1.4	...	...	...	...	...	...	...
Dry Press	...	1.2	1.6	1.4	...	...	...	...	...	...	...
Rolls	...	1.2	1.4	1.4	...	...	...	...	...	...	...
Bakery Machinery											
Dough Mixer	1.2	...	...	...	...	...	1.2	1.0	...	...	...
Compressors											
Centrifugal	1.2	1.2	...	1.4	1.4	...	...	...	1.2	...	...
Rotary	1.2	1.2	...	1.4	1.4	...	1.2	1.2	1.2	...	...
Reciprocating —											
3 or More Cyl	1.2	1.2	...	1.4	1.4	...	...	...	1.2	...	...
1 or 2 Cyl	1.4	1.4	...	1.5	1.5	...	...	...	1.2	...	...
Conveyors											
Apron	...	1.4	1.6	...	...	...	...	...	1.4	...	1.6
Belt (Ore, Coal, Sand)	...	1.2	1.4	...	...	...	...	...	1.2	...	1.4
Belt (Light Package)	...	1.0	1.1	...	...	...	...	...	1.0	...	1.2

Table 11. (*Continued*). Service Factors for Multiple V-Belt Applications

Applications	Electric Motors										
	A.C.								D.C.		
	Squirrel Cage				Synchronous		Single Phase				
	Normal Torque Line Start	Normal Torque Compensator Start	High Torque	Wound Rotor (Slip Ring)	Normal Torque	High Torque	Repulsion and Split-Phase	Capacitor	Shunt Wound	Compound Wound	Line Shaft and Clutch Shifting
	Service Factors										
Oven	...	1.0	1.1	...	...	...	...	...	1.0	...	1.2
Screw	...	1.6	1.8	...	...	...	...	...	1.6	...	1.8
Bucket	...	1.4	1.6	...	...	...	...	...	1.4	...	1.6
Pan	...	1.4	1.6	...	...	...	...	...	1.4	...	1.6
Flight	...	1.6	1.8	...	...	...	...	...	1.6	...	1.8
Elevator	...	1.4	1.6	...	...	...	...	...	1.4	...	1.6
Crushing Machinery											
Jaw Crushers	...	1.4	1.6	1.4	...	...	...	...	...	1.4	1.6
Gyratory Crushers	...	1.4	1.6	1.4	1.4	1.6	...	...	...	1.4	1.6
Cone Crushers	...	1.4	1.6	1.4	...	...	...	...	...	1.6	1.6
Crushing Rolls	...	1.4	1.6	1.4	...	...	...	...	...	1.4	1.6
Ball-Pebble and	...	1.4	1.6	1.4	1.4	1.6	...	...	...	1.4	1.6
Tube Mills	...	1.4	1.6	1.4	1.4	...	...	...	...	1.4	1.6
Fan and Blowers											
Centrifugal	1.2	1.2	...	1.4	...	...	...	...	1.2	...	...
Propeller	1.4	1.4	2.0	1.6	...	2.0	...	...	1.4	...	...
Induced Draft	1.2	1.2	...	1.4	...	...	...	...	1.4	...	...
Positive Blowers	1.6	1.6	...	2.0	2.0	2.0	...	...	...	...	...
Exhausters	1.2	1.2	...	1.4	...	...	...	...	1.4	...	1.5
Line Shafts	1.4	1.4	...	1.4	1.4	2.0	1.4	1.4	1.4	1.4	1.6
Machine Tools											
Grinders	1.2	...	...	1.4	...	...	1.2	1.0	1.2	1.2	...
Boring Mills	1.2	...	...	1.4	...	...	...	...	1.2	1.2	...
Lathes	1.0	...	...	1.2	...	...	1.0	1.0	1.0	1.0	...
Milling Machines	1.2	...	...	1.4	...	...	...	...	1.2	1.2	...
Screw Machines	1.0	...	...	1.0	...	...	1.0	1.0	1.0	1.0	...
Cam Cutters	1.0	...	...	1.0	...	...	...	...	1.0	1.0	...
Planers	1.2	...	...	1.4	...	...	1.2	1.0	1.2	1.2	...
Shapers	1.0	...	...	1.0	...	...	1.0	1.0	1.0	1.0	...
Drill Press	1.0	...	...	1.0	...	...	1.0	1.0	1.0	1.0	...
Drop Hammers	1.0	...	...	1.0	...	...	1.0	1.0	1.0	1.0	...
Shears	1.2	...	...	1.4	...	...	1.2	1.2	1.2	1.0	...
Mills											
Pebble	...	1.4	1.6	1.4	...	...	...	...	...	1.4	1.6
Rod	...	1.4	1.6	1.4	...	...	...	...	...	1.4	1.6
Ball	...	1.4	1.6	1.4	...	...	...	...	...	1.4	1.6
Roller Mills	...	1.4	1.6	1.4	...	...	...	...	...	1.4	1.6
Flaking Mills	...	1.6	1.6	1.4	...	...	...	...	...	1.4	1.6
Tumbling Barrels	...	1.6	1.6	1.4	...	...	...	...	...	1.4	1.6

Table 11 (*Continued*). Service Factors for Multiple V-Belt Applications

Applications	Electric Motors										
	A.C.								D.C.		
	Squirrel Cage				Synchronous		Single Phase				
	Normal Torque Line Start	Normal Torque Compensator Start	High Torque	Wound Rotor (Slip Ring)	Normal Torque	High Torque	Repulsion and Split-Phase	Capacitor	Shunt Wound	Compound Wound	Line Shaft and Clutch Shifting
	Service Factors										
Paper Machinery											
Jordan Engines	1.5	1.3	1.8	1.5	1.6	1.8	...	...	1.5	1.5	...
Beaters	1.4	1.4	...	1.4	...	...	...	...	1.4	1.4	1.8
Calenders	1.2	1.2	...	1.2	...	...	...	...	1.2	1.2	...
Agitators	1.2	1.0	1.4	1.2	...	...	...	...	1.2	1.2	1.6
Dryers	1.2	1.2	...	1.2	...	...	...	...	1.2	1.2	...
Paper Machines	1.4	1.4	...	1.5	...	...	...	...	1.5	1.5	1.6
Pumps											
Centrifugal	1.2	1.2	1.4	1.4	...	...	1.2	1.2	...	...	...
Gear	1.2	1.2	1.4	1.4	...	...	1.2	1.2	...	...	...
Rotary	1.2	1.2	1.4	1.4	...	...	1.2	1.2	1.2	...	...
Reciprocating —											
3 or more Cyl	1.2	1.2	...	1.4	1.4	1.6	...	...	...	...	...
1 or 2 Cyl	1.4	1.4	...	1.6	1.6	1.8	...	...	...	...	...

similarly, a B, C, D, or E size belt. For example, for a small sheave rotating at 1750 rpm and a design horsepower of 5, a size A belt would be used.

If this point falls near the line of separation between two belt size areas, then both sizes may be considered as suitable for use. For example, a design horsepower of 40 to be transmitted at a small sheave speed of 800 rpm would call for a multiple drive of either C or D size V-belts.

Horsepower Rating for Multiple V-Belts. — The following formula and accompanying table of constants may be used to determine the general horsepower rating of a single V-belt.

$$\text{H.P.} = XS^{.91} - \frac{YS}{d_e} - ZS^3 \qquad (4)$$

where, X, Y, and Z are constants as given in the accompanying table; H.P. = the recommended horsepower which must be multiplied by the appropriate correction factors for length (see Table 12) and arc of contact (see Table 13).

S = belt speed in thousands of feet per minute. This is found by the formula:

$$S = \frac{3.14 \times \text{P.D. (inches)} \times \text{R.P.M.}}{12 \times 1000}$$

d_e = equivalent diameter of small sheave which is equal to pitch diameter (in inches) multiplied by small diameter factor (Table 14). This provides ratings that compensate for the flexing effect of the small and large sheaves of the drive. The maximum value of d_e to be used in the formula is: 5 for A belts; 7 for B belts; 12 for C belts; 17 for D belts; and 28 for E belts.

Factors *X*, *Y*, and *Z* for Use in Formula 4

Factor	Regular Quality Belts					Premium Quality Belts				
	Belt Cross Section									
	A	B	C	D	E	A	B	C	D	E
	Values of X, Y, and Z to be Used in H.P. Formula									
X	1.945	3.434	6.372	13.616	19.914	2.684	4.737	8.792	18.788	24.478
Y	3.801	9.830	26.948	93.899	177.74	5.326	13.962	38.819	137.70	263.04
Z	0.0136	0.0234	0.0416	0.0848	0.1222	0.0136	0.0234	0.0416	0.0848	0.1222

Example: Find the horsepower capacity of a standard quality A60 size V-belt for a drive in which the pitch diameter of the small sheave is 3 inches and that of the large, 9 inches.

The small sheave is to rotate at 1750 R.P.M.

1. Find center distance C (Formula 3, page 952)

$$C = \frac{b + \sqrt{b^2 - 32(D - d)^2}}{16}$$

where $b = 4L - 6.28\,(D + d)$

L = 61.3 inches (Table 8)

$b = 4 \times 61.3 - 6.28(9 + 3) = 169.8$

$$C = \frac{169.8 + \sqrt{169.8^2 - 32(9 - 3)^2}}{16} = 21.0 \text{ inches}$$

2. Find arc of contact, A (Formula 5, page 960)

$$A = 180° - \frac{(D - d)60°}{C} = 180° - \frac{(9 - 3)60°}{21.0} = 163°$$

3. Find correction factors
   Length correction factor = 0.98 (Table 12)
   Arc of contact correction factor = 0.96 (Table 13)
   Small diameter factor (Speed ratio = 9 ÷ 3 = 3) = 1.14 (Table 14)
4. Compute belt speed in thousands of feet per minute:

$$S = \frac{3.14 \times \text{P.D.} \times \text{R.P.M.}}{12 \times 1000} = \frac{3.14 \times 3 \times 1750}{12 \times 1000} = 1.38$$

5. Compute equivalent diameter of small sheave

$$d_e = 3 \times 1.14 = 3.42 \text{ inches}$$

6. Compute belt H.P. using Formula 4:

$$\text{H.P.} = 1.945S^{.91} - \frac{3.801S}{d_e} - .0136S^3$$

$$= 1.945 \times 1.38^{.91} - \frac{3.801 \times 1.38}{3.42} - .0136 \times 1.38^3$$

$$= 1.945 \times 1.34 - 1.535 - .034 = 1.04$$

7. Apply length and arc of contact correction factors to get horsepower capacity:

$$1.04 \times 0.98 \times 0.96 = 0.98 \text{ H.P.}$$

8. Divide horsepower capacity into horsepower to be transmitted to obtain number of belts required for drive.

Table 12. Length Correction Factors

Standard Length Designation	Belt Cross Section A	B	C	Standard Length Designation	Belt Cross Section A	B	C	D	E
	Correction Factor				Correction Factor				
26	0.81	....	....	97	....	1.02	....	....	....
31	0.84	....	....	105	1.10	1.04	0.94	....	....
33	0.86	....	....	112	1.11	1.05	0.95	....	....
35	0.87	0.81	....	120	1.13	1.07	0.97	0.86	....
38	0.88	0.83	....	128	1.14	1.08	0.98	0.87	....
42	0.90	0.85	....	136	....	1.09	0.99	....	....
46	0.92	0.87	....	144	....	1.11	1.00	0.90	....
48	0.93	0.88	....	158	....	1.13	1.02	0.92	....
51	0.94	0.89	0.80	162	....	....	1.03	0.92	....
53	0.95	0.90	....	173	....	1.15	1.04	0.93	....
55	0.96	0.90	....	180	....	1.16	1.05	0.94	0.91
60	0.98	0.92	0.82	195	....	1.18	1.07	0.96	0.92
62	0.99	0.93	....	210	....	1.19	1.08	0.96	0.94
64	0.99	0.93	....	240	....	1.22	1.11	1.00	0.96
66	1.00	0.94	....	270	....	1.25	1.14	1.03	0.99
68	1.00	0.95	0.85	300	....	1.27	1.16	1.05	1.01
71	1.01	0.95	....	330	....	....	1.19	1.07	1.03
75	1.02	0.97	0.87	360	....	....	1.21	1.09	1.05
78	1.03	0.98	....	390	....	....	1.23	1.11	1.07
80	1.04	....	....	420	....	....	1.24	1.12	1.09
81	....	0.98	0.89	480	....	....	....	1.16	1.12
83	....	0.99	....	540	....	....	....	1.18	1.14
85	1.05	0.99	0.90	600	....	....	....	1.20	1.17
90	1.06	1.00	0.91	660	....	....	....	1.23	1.19
96	1.08	....	0.92	...	....	....	....	....	....

Arc of Contact. — The arc of contact made by the V-belt on the small sheave is of importance when computing the horsepower rating of a V-belt for a given drive. This may be found by the formula:

$$\text{Arc of Contact (degrees)} = 180° - \frac{(D - d)60°}{C} \qquad (5)$$

where D, d and C are as noted above. Correction factors, for various arcs of contact, used in finding horsepower capacities of mutiple V-belt drives (see example under Horsepower Rating for Multiple V-Belts) are given in Table 13.

Table 13. Arc of Contact Correction Factors

Arc of Contact on Small Sheave	Type of Drive: V to V	V to Flat*	Arc of Contact on Small Sheave	Type of Drive: V to V	V to Flat*
	Correction Factor			Correction Factor	
180°	1.00	.75	130°	.86	.86
170°	.98	.77	120°	.82	.82
160°	.95	.80	110°	.78	.78
150°	.92	.82	100°	.74	.74
140°	.89	.84	90°	.69	.69

* A V-Flat drive is one using a small sheave and a larger diameter flat pulley.

Table 14. Small Diameter Factors

Speed Ratio Range	Small Diameter Factor	Speed Ratio Range	Small Diameter Factor	Speed Ratio Range	Small Diameter Factor
1.000–1.019	1.00	1.110–1.142	1.05	1.341–1.429	1.10
1.020–1.032	1.01	1.143–1.178	1.06	1.430–1.562	1.11
1.033–1.055	1.02	1.179–1.222	1.07	1.563–1.814	1.12
1.056–1.081	1.03	1.223–1.274	1.08	1.815–2.948	1.13
1.082–1.109	1.04	1.275–1.340	1.09	2.949 and over	1.14

Speed of Operation. — V-belts operate most efficiently at speeds of about 4500 feet per minute. For belt speeds of 5000 feet per minute and more the sheave should be both statically and dynamically balanced. Special design and materials may also be called for and the manufacturer should be consulted. Equivalent belt speed for given sheave pitch diameter and revolutions per minute can be found in Table 3 in Flat Leather Belt section.

Use of Idlers. — According to the B. F. Goodrich Company, the most successful drives are those where an idler is not necessary and where proper tension can be had by adjusting the position of either the driver unit or the driven unit. Where these units are not adjustable, a grooved idler can be used on the inside of the drive. Such an idler should have a diameter larger than the recommended minimum sheave diameter for the belt cross section. If the idler has the smallest diameter on the drive, the idler diameter should be used in determining the horsepower per belt. The drive should be designed taking into account the smallest arc of contact whether it be on the driver or on the driven sheaves.

Some fixed-center drives do not leave enough space for a grooved idler inside and for these there is no choice but to install a flat back bend idler. Such idlers are not recommended because they are inefficient and cause trouble. The belts have a tendency to turn over; the belt life is reduced from 20 to 50 per cent; and often a second (grooved) idler must be added to the drive ahead of the flat idler to make it workable. Where a flat back bend idler is used, the belt life will be improved if in the design computations an additional 0.2 service factor (see Table 11) is employed.

Quarter-turn Drives. — V-belt quarter-turn drives are used to transmit power from a horizontal shaft to a vertical shaft or vice versa. According to the Engineering Standards for Multiple V-Belt Drives, certain precautions must be taken in setting up this type of drive: (a) Direction of rotation must be such that the tight side of the drive is on the bottom; (b) The axis of the vertical shaft should lie in a plane perpendicular to the horizontal shaft, and intersecting it at the center of the face of the sheave on the horizontal shaft; (c) the center of the face of the sheave of the vertical shaft should be below the axis of the horizontal shaft by an amount "Y" which depends on the center distance and is shown in Table 15.

Table 15. "Y" Dimensions for Quarter-turn Drives

Center Distance	60	80	100	120	140	160	180	200	220	240
"Y" Dimension	2½	2¾	3	4	5¼	6½	7¾	9	10½	12

All dimensions in inches.

Deep grooved sheaves (see Table 9) should always be used. The drive should have a minimum center distance of $5.5\,(D + (N - 1)S + w)$ where, D = pitch diameter of large sheave; N = number of belts; S = deep groove spacing (see Table 9) and w = nominal belt top width (see Table 7).

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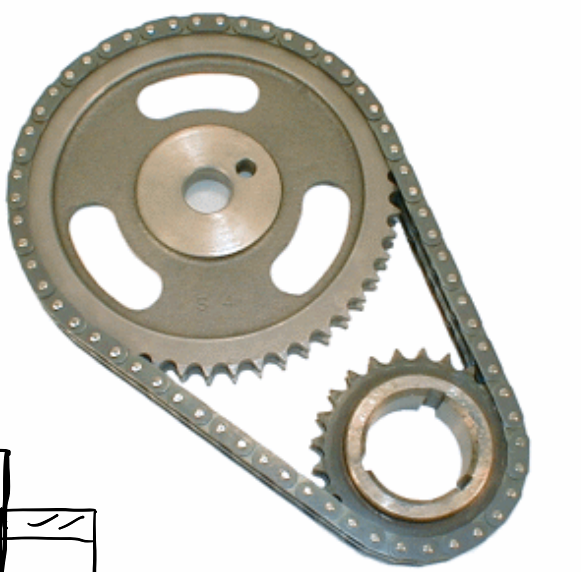

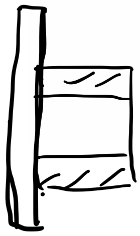


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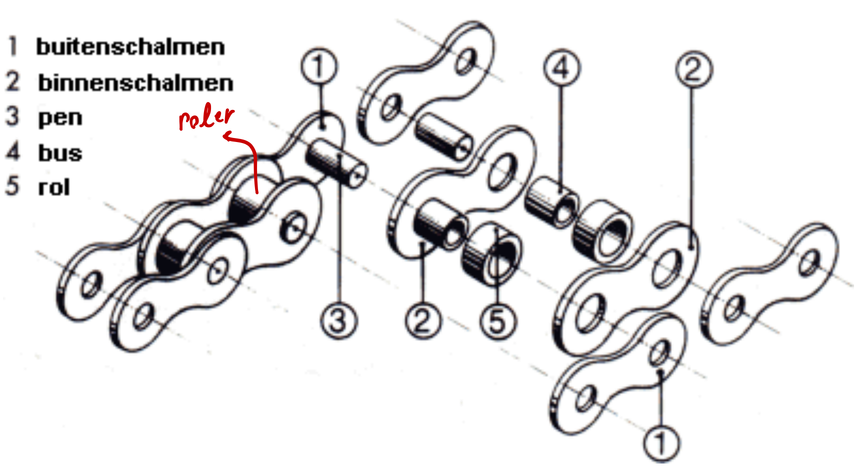
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Lubrication. — It has been shown that a separating wedge of fluid lubricant is formed in operating chain joints much like that formed in journal bearings. Therefore, fluid lubricant must be applied to assure an oil supply to the joints and minimize metal-to-metal contact. Lubrication, if supplied in sufficient volume, also provides effective cooling and impact damping at higher speeds. For this reason, it is important that lubrication recommendations be followed. *The ratings in Table 15 apply only to drives lubricated in the manner specified in this table.*

Chain drives should be protected against dirt and moisture and the oil supply kept free of contamination. Periodic oil change is desirable. A good grade of non-detergent petroleum base oil is recommended. Heavy oils and greases are generally too stiff to enter and fill the chain joints. The following lubricant viscosities are recommended: For temperatures of 20° to 40° F, use SAE 20 lubricant; for 40° to 100°, use SAE 30; for 100° to 120°, use SAE 40; and for 120° to 140°, use SAE 50.

There are three basic types of lubrication for roller chain drives. The recommended type shown in Table 15 as Type A, Type B, or Type C is influenced by the chain speed and the amount of power transmitted. These are *minimum* lubrication requirements and the use of a better type (for example, Type C instead of Type B) is acceptable and may be beneficial. Chain life can vary appreciably depending upon the way the drive is lubricated. The better the chain lubrication, the longer the chain life. For this reason, it is important that the lubrication recommendations be followed when using the ratings given in Table 15. The types of lubrication are as follows:

Type A — Manual or Drip Lubrication: In manual lubrication, oil is applied copiously with a brush or spout can at least once every eight hours of operation. Volume and frequency should be sufficient to prevent overheating of the chain or discoloration of the chain joints. In drip lubrication, oil drops from a drip lubricator are directed between the link plate edges. The volume and frequency should be sufficient to prevent discoloration of the lubricant in the chain joints. Precaution must be taken against misdirection of the drops by windage.

Type B — Bath or Disc Lubrication: In bath lubrication, the lower strand of the chain runs through a sump of oil in the drive housing. The oil level should reach the pitch line of the chain at its lowest point while operating. In disc lubrication, the chain operates above the oil level. The disc picks up oil from the sump and deposits it onto the chain, usually by means of a trough. The diameter of the disc should be such as to produce rim speeds of between 600 and 8000 feet per minute.

Type C — Oil Stream Lubrication: The lubricant is usually supplied by a circulating pump capable of supplying each chain drive with a continuous stream of oil. The oil should be applied inside the chain loop evenly across the chain width, and directed at the slack strand.

The chain manufacturer should be consulted when it appears desirable to use a type of lubricant other than that recommended.

Installation and Alignment. — Sprockets should have the tooth form, thickness, profile, and diameters conforming to the ANSI B29.1 Standard. For maximum service life small sprockets operating at moderate to high speeds, or near the rated horsepower, should have hardened teeth. Normally, large sprockets should not exceed 120 teeth.

In general a center distance of 30 to 50 chain pitches is most desirable. The distance between sprocket centers should provide at least a 120 degree chain wrap on the smaller sprocket. Drives may be installed with either adjustable or fixed center distances. Adjustable centers simplify the control of chain slack. Sufficient housing clearance must always be provided for the chain slack to obtain full chain life.

Accurate alignment of shafts and sprocket tooth faces provides uniform distribution of the load across the entire chain width and contributes substantially to optimum drive life. Shafting, bearings, and foundations should be suitable to maintain the initial alignment. Periodic maintenance should include an inspection of alignment.

Table 15. Horsepower Ratings for Roller Chain — 1975

To properly use this table the following factors must be taken into consideration:

1. Service Factors
2. Multiple Strand Factors
3. Lubrication.

Service Factors: See Table 14.

Multiple Strand Factors: For two strands, the multiple strand factor is 1.7; for three strands, it is 2.5; and for four strands, it is 3.3.

Lubrication: Type A — Manual or Drip Lubrication
Type B — Bath or Disc Lubrication
Type C — Oil Stream Lubrication

Required type of lubrication is indicated at the bottom of each roller chain size section of the table.

For a description of each type of lubrication, see page 982.

To find the required horsepower table rating, use the following formula:

$$\text{Required hp Table Rating} = \frac{\text{hp to be transmitted} \times \text{Service Factor}}{\text{Multiple Strand Factor}}$$

¼-inch Pitch Standard Single-Strand Roller Chain — No. 25

No. of Teeth Small Spkt.	Revolutions per Minute — Small Sprocket*												
	50	100	300	500	700	900	1200	1500	1800	2100	2500	3000	3500
	Horsepower Rating												
9	0.02	0.04	0.12	0.18	0.25	0.31	0.41	0.50	0.58	0.67	0.79	0.93	1.06
10	0.03	0.05	0.13	0.21	0.28	0.35	0.45	0.56	0.65	0.75	0.88	1.04	1.19
11	0.03	0.05	0.14	0.23	0.31	0.39	0.50	0.62	0.73	0.83	0.98	1.15	1.32
12	0.03	0.06	0.16	0.25	0.34	0.43	0.55	0.68	0.80	0.92	1.07	1.26	1.45
13	0.04	0.06	0.17	0.27	0.37	0.47	0.60	0.74	0.87	1.00	1.17	1.38	1.58
14	0.04	0.07	0.19	0.30	0.40	0.50	0.65	0.80	0.94	1.08	1.27	1.49	1.71
15	0.04	0.08	0.20	0.32	0.43	0.54	0.70	0.86	1.01	1.17	1.36	1.61	1.85
16	0.04	0.08	0.22	0.34	0.47	0.58	0.76	0.92	1.09	1.25	1.46	1.72	1.98
17	0.05	0.09	0.23	0.37	0.50	0.62	0.81	0.99	1.16	1.33	1.56	1.84	2.11
18	0.05	0.09	0.25	0.39	0.53	0.66	0.86	1.05	1.24	1.42	1.66	1.96	2.25
19	0.05	0.10	0.26	0.41	0.56	0.70	0.91	1.11	1.31	1.50	1.76	2.07	2.38
20	0.06	0.10	0.28	0.44	0.59	0.74	0.96	1.17	1.38	1.59	1.86	2.19	2.52
21	0.06	0.11	0.29	0.46	0.62	0.78	1.01	1.24	1.46	1.68	1.96	2.31	2.66
22	0.06	0.11	0.31	0.48	0.66	0.82	1.07	1.30	1.53	1.76	2.06	2.43	2.79
23	0.06	0.12	0.32	0.51	0.69	0.86	1.12	1.37	1.61	1.85	2.16	2.55	2.93
24	0.07	0.13	0.34	0.53	0.72	0.90	1.17	1.43	1.69	1.94	2.27	2.67	3.07
25	0.07	0.13	0.35	0.56	0.75	0.94	1.22	1.50	1.76	2.02	2.37	2.79	3.21
26	0.07	0.14	0.37	0.58	0.79	0.98	1.28	1.56	1.84	2.11	2.47	2.91	3.34
28	0.08	0.15	0.40	0.63	0.85	1.07	1.38	1.69	1.99	2.29	2.68	3.15	3.62
30	0.08	0.16	0.43	0.68	0.92	1.15	1.49	1.82	2.15	2.46	2.88	3.40	3.90
32	0.09	0.17	0.46	0.73	0.98	1.23	1.60	1.95	2.30	2.64	3.09	3.64	4.18
35	0.10	0.19	0.51	0.80	1.08	1.36	1.76	2.15	2.53	2.91	3.41	4.01	4.61
40	0.12	0.22	0.58	0.92	1.25	1.57	2.03	2.48	2.93	3.36	3.93	4.64	5.32
45	0.13	0.25	0.66	1.05	1.42	1.78	2.31	2.82	3.32	3.82	4.47	5.26	6.05
	Type A				Type B								

* For rpm above 3500, see ANSI B29.1-1975.

Table 15 *(Continued)*. **Horsepower Ratings for Roller Chain — 1975**

⅜-inch Pitch Standard Single-Strand Roller Chain — No. 35													
No. of Teeth Small Spkt.	Revolutions per Minute — Small Sprocket*												
	50	100	300	500	700	900	1200	1500	1800	2100	2500	3000	3500
	Horsepower Rating												
9	0.08	0.15	0.39	0.62	0.84	1.06	1.37	1.68	1.98	2.27	2.65	2.17	1.73
10	0.09	0.16	0.44	0.70	0.95	1.19	1.54	1.88	2.21	2.54	2.97	2.55	2.02
11	0.10	0.18	0.49	0.77	1.05	1.31	1.70	2.08	2.45	2.82	3.30	2.94	2.33
12	0.11	0.20	0.54	0.85	1.15	1.44	1.87	2.29	2.70	3.10	3.62	3.35	2.66
13	0.12	0.22	0.59	0.93	1.26	1.57	2.04	2.49	2.94	3.38	3.95	3.77	3.00
14	0.13	0.24	0.63	1.01	1.36	1.71	2.21	2.70	3.18	3.66	4.28	4.22	3.35
15	0.14	0.25	0.68	1.08	1.47	1.84	2.38	2.91	3.43	3.94	4.61	4.68	3.71
16	0.15	0.27	0.73	1.16	1.57	1.97	2.55	3.12	3.68	4.22	4.94	5.15	4.09
17	0.16	0.29	0.78	1.24	1.68	2.10	2.73	3.33	3.93	4.51	5.28	5.64	4.48
18	0.17	0.31	0.83	1.32	1.78	2.24	2.90	3.54	4.18	4.80	5.61	6.15	4.88
19	0.18	0.33	0.88	1.40	1.89	2.37	3.07	3.76	4.43	5.09	5.95	6.67	5.29
20	0.19	0.35	0.93	1.48	2.00	2.51	3.25	3.97	4.68	5.38	6.29	7.20	5.72
21	0.20	0.37	0.98	1.56	2.11	2.64	3.42	4.19	4.93	5.67	6.63	7.75	6.15
22	0.21	0.38	1.03	1.64	2.22	2.78	3.60	4.40	5.19	5.96	6.97	8.21	6.59
23	0.22	0.40	1.08	1.72	2.33	2.92	3.78	4.62	5.44	6.25	7.31	8.62	7.05
24	0.23	0.42	1.14	1.80	2.44	3.05	3.96	4.84	5.70	6.55	7.66	9.02	7.51
25	0.24	0.44	1.19	1.88	2.55	3.19	4.13	5.05	5.95	6.84	8.00	9.43	7.99
26	0.25	0.46	1.24	1.96	2.66	3.33	4.31	5.27	6.21	7.14	8.35	9.84	8.47
28	0.27	0.50	1.34	2.12	2.88	3.61	4.67	5.71	6.73	7.73	9.05	10.7	9.47
30	0.29	0.54	1.45	2.29	3.10	3.89	5.03	6.15	7.25	8.33	9.74	11.5	10.5
32	0.31	0.58	1.55	2.45	3.32	4.17	5.40	6.60	7.77	8.93	10.4	12.3	11.6
35	0.34	0.64	1.71	2.70	3.66	4.59	5.95	7.27	8.56	9.84	11.5	13.6	13.2
40	0.39	0.73	1.97	3.12	4.23	5.30	6.87	8.40	9.89	11.4	13.3	15.7	16.2
45	0.45	0.83	2.24	3.55	4.80	6.02	7.80	9.53	11.2	12.9	15.1	17.8	19.3
	Type A		Type B							Type C			

½-inch Pitch Standard Single-Strand Roller Chain — No. 40													
No. of Teeth Small Spkt.	Revolutions per Minute — Small Sprocket*												
	50	100	200	300	400	500	700	900	1000	1200	1400	1600	1800
	Horsepower Rating												
9	0.19	0.35	0.65	0.93	1.21	1.48	2.00	2.51	2.75	3.25	3.73	4.12	3.45
10	0.21	0.39	0.73	1.04	1.35	1.65	2.24	2.81	3.09	3.64	4.18	4.71	4.04
11	0.23	0.43	0.80	1.16	1.50	1.83	2.48	3.11	3.42	4.03	4.63	5.22	4.66
12	0.25	0.47	0.88	1.27	1.65	2.01	2.73	3.42	3.76	4.43	5.09	5.74	5.31
13	0.28	0.52	0.96	1.39	1.80	2.20	2.97	3.73	4.10	4.83	5.55	6.26	5.99
14	0.30	0.56	1.04	1.50	1.95	2.38	3.22	4.04	4.44	5.23	6.01	6.78	6.70
15	0.32	0.60	1.12	1.62	2.10	2.56	3.47	4.35	4.78	5.64	6.47	7.30	7.43
16	0.35	0.65	1.20	1.74	2.25	2.75	3.72	4.66	5.13	6.04	6.94	7.83	8.18
17	0.37	0.69	1.29	1.85	2.40	2.93	3.97	4.98	5.48	6.45	7.41	8.36	8.96
18	0.39	0.73	1.37	1.97	2.55	3.12	4.22	5.30	5.82	6.86	7.88	8.89	9.76
19	0.42	0.78	1.45	2.09	2.71	3.31	4.48	5.62	6.17	7.27	8.36	9.42	10.5
20	0.44	0.82	1.53	2.21	2.86	3.50	4.73	5.94	6.53	7.69	8.83	9.96	11.1
21	0.46	0.87	1.62	2.33	3.02	3.69	4.99	6.26	6.88	8.11	9.31	10.5	11.7
22	0.49	0.91	1.70	2.45	3.17	3.88	5.25	6.58	7.23	8.52	9.79	11.0	12.3
23	0.51	0.96	1.78	2.57	3.33	4.07	5.51	6.90	7.59	8.94	10.3	11.6	12.9
24	0.54	1.00	1.87	2.69	3.48	4.26	5.76	7.23	7.95	9.36	10.8	12.1	13.5
25	0.56	1.05	1.95	2.81	3.64	4.45	6.02	7.55	8.30	9.78	11.2	12.7	14.1
26	0.58	1.09	2.04	2.93	3.80	4.64	6.28	7.88	8.66	10.2	11.7	13.2	14.7
28	0.63	1.18	2.20	3.18	4.11	5.03	6.81	8.54	9.39	11.1	12.7	14.3	15.9
30	0.68	1.27	2.38	3.42	4.43	5.42	7.33	9.20	10.1	11.9	13.7	15.4	17.2
32	0.73	1.36	2.55	3.67	4.75	5.81	7.86	9.86	10.8	12.8	14.7	16.5	18.4
35	0.81	1.50	2.81	4.04	5.24	6.40	8.66	10.9	11.9	14.1	16.2	18.2	20.3
40	0.93	1.74	3.24	4.67	6.05	7.39	10.0	12.5	13.8	16.3	18.7	21.1	23.4
45	1.06	1.97	3.68	5.30	6.87	8.40	11.4	14.2	15.7	18.5	21.2	23.9	26.6
	Type A		Type B								Type C		

For use of table see page 983.
*For lower or higher rpms see ANSI B29.1-1975.

Table 15 *(Continued)*. **Horsepower Ratings for Roller Chain — 1975**

½-inch Pitch Light Weight Machinery Roller Chain — No. 41													
No. of Teeth Small Spkt.	Revolutions per Minute — Small Sprocket*												
	10	25	50	100	200	300	400	500	700	900	1000	1200	1400
	Horsepower Rating												
9	0.02	0.05	0.10	0.19	0.36	0.51	0.66	0.81	1.10	1.38	1.52	1.27	1.01
10	0.03	0.06	0.11	0.21	0.40	0.57	0.74	0.91	1.23	1.54	1.70	1.49	1.18
11	0.03	0.07	0.13	0.24	0.44	0.64	0.82	1.01	1.37	1.71	1.88	1.71	1.36
12	0.03	0.07	0.14	0.26	0.49	0.70	0.91	1.11	1.50	1.88	2.07	1.95	1.55
13	0.04	0.08	0.15	0.28	0.53	0.76	0.99	1.21	1.63	2.05	2.25	2.20	1.75
14	0.04	0.09	0.16	0.31	0.57	0.83	1.07	1.31	1.77	2.22	2.44	2.46	1.95
15	0.04	0.09	0.18	0.33	0.62	0.89	1.15	1.41	1.91	2.39	2.63	2.73	2.17
16	0.04	0.10	0.19	0.36	0.66	0.95	1.24	1.51	2.05	2.57	2.82	3.01	2.39
17	0.05	0.11	0.20	0.38	0.71	1.02	1.32	1.61	2.18	2.74	3.01	3.29	2.61
18	0.05	0.12	0.22	0.40	0.75	1.08	1.40	1.72	2.32	2.91	3.20	3.59	2.85
19	0.05	0.12	0.23	0.43	0.80	1.15	1.49	1.82	2.46	3.09	3.40	3.89	3.09
20	0.06	0.13	0.24	0.45	0.84	1.21	1.57	1.92	2.60	3.26	3.59	4.20	3.33
21	0.06	0.14	0.26	0.48	0.89	1.28	1.66	2.03	2.74	3.44	3.78	4.46	3.59
22	0.06	0.14	0.27	0.50	0.93	1.35	1.74	2.13	2.89	3.62	3.98	4.69	3.85
23	0.06	0.15	0.28	0.53	0.98	1.41	1.83	2.24	3.03	3.80	4.17	4.92	4.11
24	0.07	0.16	0.29	0.55	1.03	1.48	1.92	2.34	3.17	3.97	4.37	5.15	4.38
25	0.07	0.17	0.31	0.57	1.07	1.55	2.00	2.45	3.31	4.15	4.57	5.38	4.66
26	0.07	0.17	0.32	0.60	1.12	1.61	2.09	2.55	3.46	4.33	4.76	5.61	4.94
28	0.08	0.19	0.35	0.65	1.21	1.75	2.26	2.77	3.74	4.69	5.16	6.08	5.52
30	0.08	0.20	0.38	0.70	1.31	1.88	2.44	2.98	4.03	5.06	5.56	6.55	6.13
32	0.09	0.22	0.40	0.75	1.40	2.02	2.61	3.20	4.33	5.42	5.96	7.03	6.75
35	0.10	0.24	0.44	0.83	1.54	2.22	2.88	3.52	4.76	5.97	6.57	7.74	7.72
40	0.12	0.27	0.51	0.96	1.78	2.57	3.33	4.07	5.50	6.90	7.59	8.94	9.43
45	0.14	0.31	0.58	1.08	2.02	2.92	3.78	4.62	6.25	7.84	8.62	10.2	11.3
	Type A				Type B								T'p C

⅝-inch Pitch Standard Single-Strand Roller Chain — No. 50													
No. of Teeth Small Spkt.	Revolutions per Minute — Small Sprocket*												
	25	50	100	200	300	400	500	700	900	1000	1200	1400	1600
	Horsepower Rating												
9	0.19	0.36	0.67	1.26	1.81	2.35	2.87	3.89	4.88	5.36	6.32	6.02	4.92
10	0.22	0.41	0.76	1.41	2.03	2.63	3.22	4.36	5.46	6.01	7.08	7.05	5.77
11	0.24	0.45	0.84	1.56	2.25	2.92	3.57	4.83	6.06	6.66	7.85	8.13	6.65
12	0.26	0.49	0.92	1.72	2.47	3.21	3.92	5.31	6.65	7.31	8.62	9.26	7.58
13	0.29	0.54	1.00	1.87	2.70	3.50	4.27	5.78	7.25	7.97	9.40	10.4	8.55
14	0.31	0.58	1.09	2.03	2.92	3.79	4.63	6.27	7.86	8.64	10.2	11.7	9.55
15	0.34	0.63	1.17	2.19	3.15	4.08	4.99	6.75	8.47	9.31	11.0	12.6	10.6
16	0.36	0.67	1.26	2.34	3.38	4.37	5.35	7.24	9.08	9.98	11.8	13.5	11.7
17	0.39	0.72	1.34	2.50	3.61	4.67	5.71	7.73	9.69	10.7	12.6	14.4	12.8
18	0.41	0.76	1.43	2.66	3.83	4.97	6.07	8.22	10.3	11.3	13.4	15.3	13.9
19	0.43	0.81	1.51	2.82	4.07	5.27	6.44	8.72	10.9	12.0	14.2	16.3	15.1
20	0.46	0.86	1.60	2.98	4.30	5.57	6.80	9.21	11.5	12.7	15.0	17.2	16.3
21	0.48	0.90	1.69	3.14	4.53	5.87	7.17	9.71	12.2	13.4	15.8	18.1	17.6
22	0.51	0.95	1.77	3.31	4.76	6.17	7.54	10.2	12.8	14.1	16.6	19.1	18.8
23	0.53	1.00	1.86	3.47	5.00	6.47	7.91	10.7	13.4	14.8	17.4	20.0	20.1
24	0.56	1.04	1.95	3.63	5.23	6.78	8.29	11.2	14.1	15.5	18.2	20.9	21.4
25	0.58	1.09	2.03	3.80	5.47	7.08	8.66	11.7	14.7	16.2	19.0	21.9	22.8
26	0.61	1.14	2.12	3.96	5.70	7.39	9.03	12.2	15.3	16.9	19.9	22.8	24.2
28	0.66	1.23	2.30	4.29	6.18	8.01	9.79	13.2	16.6	18.3	21.5	24.7	27.0
30	0.71	1.33	2.48	4.62	6.66	8.63	10.5	14.3	17.9	19.7	23.2	26.6	30.0
32	0.76	1.42	2.66	4.96	7.14	9.25	11.3	15.3	19.2	21.1	24.9	28.6	32.2
35	0.84	1.57	2.93	5.46	7.86	10.2	12.5	16.9	21.1	23.2	27.4	31.5	35.5
40	0.97	1.81	3.38	6.31	9.08	11.8	14.4	19.5	24.4	26.8	31.6	36.3	41.0
45	1.10	2.06	3.84	7.16	10.3	13.4	16.3	22.1	27.7	30.5	35.9	41.3	46.5
	Type A			Type B					Type C				

For use of table see page 983.
*For lower or higher rpms see ANSI B29.1-1975.

Table 15 *(Continued)*. **Horsepower Ratings for Roller Chain—1975**

⅜-inch Pitch Standard Single-Strand Roller Chain—No. 35

No. of Teeth Small Spkt.	Revolutions per Minute—Small Sprocket*												
	50	100	300	500	700	900	1200	1500	1800	2100	2500	3000	3500
	Horsepower Rating												
9	0.08	0.15	0.39	0.62	0.84	1.06	1.37	1.68	1.98	2.27	2.65	2.17	1.73
10	0.09	0.16	0.44	0.70	0.95	1.19	1.54	1.88	2.21	2.54	2.97	2.55	2.02
11	0.10	0.18	0.49	0.77	1.05	1.31	1.70	2.08	2.45	2.82	3.30	2.94	2.33
12	0.11	0.20	0.54	0.85	1.15	1.44	1.87	2.29	2.70	3.10	3.62	3.35	2.66
13	0.12	0.22	0.59	0.93	1.26	1.57	2.04	2.49	2.94	3.38	3.95	3.77	3.00
14	0.13	0.24	0.63	1.01	1.36	1.71	2.21	2.70	3.18	3.66	4.28	4.22	3.35
15	0.14	0.25	0.68	1.08	1.47	1.84	2.38	2.91	3.43	3.94	4.61	4.68	3.71
16	0.15	0.27	0.73	1.16	1.57	1.97	2.55	3.12	3.68	4.22	4.94	5.15	4.09
17	0.16	0.29	0.78	1.24	1.68	2.10	2.73	3.33	3.93	4.51	5.28	5.64	4.48
18	0.17	0.31	0.83	1.32	1.78	2.24	2.90	3.54	4.18	4.80	5.61	6.15	4.88
19	0.18	0.33	0.88	1.40	1.89	2.37	3.07	3.76	4.43	5.09	5.95	6.67	5.29
20	0.19	0.35	0.93	1.48	2.00	2.51	3.25	3.97	4.68	5.38	6.29	7.20	5.72
21	0.20	0.37	0.98	1.56	2.11	2.64	3.42	4.19	4.93	5.67	6.63	7.75	6.15
22	0.21	0.38	1.03	1.64	2.22	2.78	3.60	4.40	5.19	5.96	6.97	8.21	6.59
23	0.22	0.40	1.08	1.72	2.33	2.92	3.78	4.62	5.44	6.25	7.31	8.62	7.05
24	0.23	0.42	1.14	1.80	2.44	3.05	3.96	4.84	5.70	6.55	7.66	9.02	7.51
25	0.24	0.44	1.19	1.88	2.55	3.19	4.13	5.05	5.95	6.84	8.00	9.43	7.99
26	0.25	0.46	1.24	1.96	2.66	3.33	4.31	5.27	6.21	7.14	8.35	9.84	8.47
28	0.27	0.50	1.34	2.12	2.88	3.61	4.67	5.71	6.73	7.73	9.05	10.7	9.47
30	0.29	0.54	1.45	2.29	3.10	3.89	5.03	6.15	7.25	8.33	9.74	11.5	10.5
32	0.31	0.58	1.55	2.45	3.32	4.17	5.40	6.60	7.77	8.93	10.4	12.3	11.6
35	0.34	0.64	1.71	2.70	3.66	4.59	5.95	7.27	8.56	9.84	11.5	13.6	13.2
40	0.39	0.73	1.97	3.12	4.23	5.30	6.87	8.40	9.89	11.4	13.3	15.7	16.2
45	0.45	0.83	2.24	3.55	4.80	6.02	7.80	9.53	11.2	12.9	15.1	17.8	19.3
	Type A		Type B							Type C			

½-inch Pitch Standard Single-Strand Roller Chain—No. 40

No. of Teeth Small Spkt.	Revolutions per Minute—Small Sprocket*												
	50	100	200	300	400	500	700	900	1000	1200	1400	1600	1800
	Horsepower Rating												
9	0.19	0.35	0.65	0.93	1.21	1.48	2.00	2.51	2.75	3.25	3.73	4.12	3.45
10	0.21	0.39	0.73	1.04	1.35	1.65	2.24	2.81	3.09	3.64	4.18	4.71	4.04
11	0.23	0.43	0.80	1.16	1.50	1.83	2.48	3.11	3.42	4.03	4.63	5.22	4.66
12	0.25	0.47	0.88	1.27	1.65	2.01	2.73	3.42	3.76	4.43	5.09	5.74	5.31
13	0.28	0.52	0.96	1.39	1.80	2.20	2.97	3.73	4.10	4.83	5.55	6.26	5.99
14	0.30	0.56	1.04	1.50	1.95	2.38	3.22	4.04	4.44	5.23	6.01	6.78	6.70
15	0.32	0.60	1.12	1.62	2.10	2.56	3.47	4.35	4.78	5.64	6.47	7.30	7.43
16	0.35	0.65	1.20	1.74	2.25	2.75	3.72	4.66	5.13	6.04	6.94	7.83	8.18
17	0.37	0.69	1.29	1.85	2.40	2.93	3.97	4.98	5.48	6.45	7.41	8.36	8.96
18	0.39	0.73	1.37	1.97	2.55	3.12	4.22	5.30	5.82	6.86	7.88	8.89	9.76
19	0.42	0.78	1.45	2.09	2.71	3.31	4.48	5.62	6.17	7.27	8.36	9.42	10.5
20	0.44	0.82	1.53	2.21	2.86	3.50	4.73	5.94	6.53	7.69	8.83	9.96	11.1
21	0.46	0.87	1.62	2.33	3.02	3.69	4.99	6.26	6.88	8.11	9.31	10.5	11.7
22	0.49	0.91	1.70	2.45	3.17	3.88	5.25	6.58	7.23	8.52	9.79	11.0	12.3
23	0.51	0.96	1.78	2.57	3.33	4.07	5.51	6.90	7.59	8.94	10.3	11.6	12.9
24	0.54	1.00	1.87	2.69	3.48	4.26	5.76	7.23	7.95	9.36	10.8	12.1	13.5
25	0.56	1.05	1.95	2.81	3.64	4.45	6.02	7.55	8.30	9.78	11.2	12.7	14.1
26	0.58	1.09	2.04	2.93	3.80	4.64	6.28	7.88	8.66	10.2	11.7	13.2	14.7
28	0.63	1.18	2.20	3.18	4.11	5.03	6.81	8.54	9.39	11.1	12.7	14.3	15.9
30	0.68	1.27	2.38	3.42	4.43	5.42	7.33	9.20	10.1	11.9	13.7	15.4	17.2
32	0.73	1.36	2.55	3.67	4.75	5.81	7.86	9.86	10.8	12.8	14.7	16.5	18.4
35	0.81	1.50	2.81	4.04	5.24	6.40	8.66	10.9	11.9	14.1	16.2	18.2	20.3
40	0.93	1.74	3.24	4.67	6.05	7.39	10.0	12.5	13.8	16.3	18.7	21.1	23.4
45	1.06	1.97	3.68	5.30	6.87	8.40	11.4	14.2	15.7	18.5	21.2	23.9	26.6
	Type A		Type B								Type C		

For use of table see page 983.
*For lower or higher rpms see ANSI B29.1-1975.

Table 15 *(Continued)*. **Horsepower Ratings for Roller Chain—1975**

½-inch Pitch Light Weight Machinery Roller Chain—No. 41

No. of Teeth Small Spkt.	Revolutions per Minute—Small Sprocket*												
	10	25	50	100	200	300	400	500	700	900	1000	1200	1400
	Horsepower Rating												
9	0.02	0.05	0.10	0.19	0.36	0.51	0.66	0.81	1.10	1.38	1.52	1.27	1.01
10	0.03	0.06	0.11	0.21	0.40	0.57	0.74	0.91	1.23	1.54	1.70	1.49	1.18
11	0.03	0.07	0.13	0.24	0.44	0.64	0.82	1.01	1.37	1.71	1.88	1.71	1.36
12	0.03	0.07	0.14	0.26	0.49	0.70	0.91	1.11	1.50	1.88	2.07	1.95	1.55
13	0.04	0.08	0.15	0.28	0.53	0.76	0.99	1.21	1.63	2.05	2.25	2.20	1.75
14	0.04	0.09	0.16	0.31	0.57	0.83	1.07	1.31	1.77	2.22	2.44	2.46	1.95
15	0.04	0.09	0.18	0.33	0.62	0.89	1.15	1.41	1.91	2.39	2.63	2.73	2.17
16	0.04	0.10	0.19	0.36	0.66	0.95	1.24	1.51	2.05	2.57	2.82	3.01	2.39
17	0.05	0.11	0.20	0.38	0.71	1.02	1.32	1.61	2.18	2.74	3.01	3.29	2.61
18	0.05	0.12	0.22	0.40	0.75	1.08	1.40	1.72	2.32	2.91	3.20	3.59	2.85
19	0.05	0.12	0.23	0.43	0.80	1.15	1.49	1.82	2.46	3.09	3.40	3.89	3.09
20	0.06	0.13	0.24	0.45	0.84	1.21	1.57	1.92	2.60	3.26	3.59	4.20	3.33
21	0.06	0.14	0.26	0.48	0.89	1.28	1.66	2.03	2.74	3.44	3.78	4.46	3.59
22	0.06	0.14	0.27	0.50	0.93	1.35	1.74	2.13	2.89	3.62	3.98	4.69	3.85
23	0.06	0.15	0.28	0.53	0.98	1.41	1.83	2.24	3.03	3.80	4.17	4.92	4.11
24	0.07	0.16	0.29	0.55	1.03	1.48	1.92	2.34	3.17	3.97	4.37	5.15	4.38
25	0.07	0.17	0.31	0.57	1.07	1.55	2.00	2.45	3.31	4.15	4.57	5.38	4.66
26	0.07	0.17	0.32	0.60	1.12	1.61	2.09	2.55	3.46	4.33	4.76	5.61	4.94
28	0.08	0.19	0.35	0.65	1.21	1.75	2.26	2.77	3.74	4.69	5.16	6.08	5.52
30	0.08	0.20	0.38	0.70	1.31	1.88	2.44	2.98	4.03	5.06	5.56	6.55	6.13
32	0.09	0.22	0.40	0.75	1.40	2.02	2.61	3.20	4.33	5.42	5.96	7.03	6.75
35	0.10	0.24	0.44	0.83	1.54	2.22	2.88	3.52	4.76	5.97	6.57	7.74	7.72
40	0.12	0.27	0.51	0.96	1.78	2.57	3.33	4.07	5.50	6.90	7.59	8.94	9.43
45	0.14	0.31	0.58	1.08	2.02	2.92	3.78	4.62	6.25	7.84	8.62	10.2	11.3
	Type A				Type B								T'p C

⅝-inch Pitch Standard Single-Strand Roller Chain—No. 50

No. of Teeth Small Spkt.	Revolutions per Minute—Small Sprocket*												
	25	50	100	200	300	400	500	700	900	1000	1200	1400	1600
	Horsepower Rating												
9	0.19	0.36	0.67	1.26	1.81	2.35	2.87	3.89	4.88	5.36	6.32	6.02	4.92
10	0.22	0.41	0.76	1.41	2.03	2.63	3.22	4.36	5.46	6.01	7.08	7.05	5.77
11	0.24	0.45	0.84	1.56	2.25	2.92	3.57	4.83	6.06	6.66	7.85	8.13	6.65
12	0.26	0.49	0.92	1.72	2.47	3.21	3.92	5.31	6.65	7.31	8.62	9.26	7.58
13	0.29	0.54	1.00	1.87	2.70	3.50	4.27	5.78	7.25	7.97	9.40	10.4	8.55
14	0.31	0.58	1.09	2.03	2.92	3.79	4.63	6.27	7.86	8.64	10.2	11.7	9.55
15	0.34	0.63	1.17	2.19	3.15	4.08	4.99	6.75	8.47	9.31	11.0	12.6	10.6
16	0.36	0.67	1.26	2.34	3.38	4.37	5.35	7.24	9.08	9.98	11.8	13.5	11.7
17	0.39	0.72	1.34	2.50	3.61	4.67	5.71	7.73	9.69	10.7	12.6	14.4	12.8
18	0.41	0.76	1.43	2.66	3.83	4.97	6.07	8.22	10.3	11.3	13.4	15.3	13.9
19	0.43	0.81	1.51	2.82	4.07	5.27	6.44	8.72	10.9	12.0	14.2	16.3	15.1
20	0.46	0.86	1.60	2.98	4.30	5.57	6.80	9.21	11.5	12.7	15.0	17.2	16.3
21	0.48	0.90	1.69	3.14	4.53	5.87	7.17	9.71	12.2	13.4	15.8	18.1	17.6
22	0.51	0.95	1.77	3.31	4.76	6.17	7.54	10.2	12.8	14.1	16.6	19.1	18.8
23	0.53	1.00	1.86	3.47	5.00	6.47	7.91	10.7	13.4	14.8	17.4	20.0	20.1
24	0.56	1.04	1.95	3.63	5.23	6.78	8.29	11.2	14.1	15.5	18.2	20.9	21.4
25	0.58	1.09	2.03	3.80	5.47	7.08	8.66	11.7	14.7	16.2	19.0	21.9	22.8
26	0.61	1.14	2.12	3.96	5.70	7.39	9.03	12.2	15.3	16.9	19.9	22.8	24.2
28	0.66	1.23	2.30	4.29	6.18	8.01	9.79	13.2	16.6	18.3	21.5	24.7	27.0
30	0.71	1.33	2.48	4.62	6.66	8.63	10.5	14.3	17.9	19.7	23.2	26.6	30.0
32	0.76	1.42	2.66	4.96	7.14	9.25	11.3	15.3	19.2	21.1	24.9	28.6	32.2
35	0.84	1.57	2.93	5.46	7.86	10.2	12.5	16.9	21.1	23.2	27.4	31.5	35.5
40	0.97	1.81	3.38	6.31	9.08	11.8	14.4	19.5	24.4	26.8	31.6	36.3	41.0
45	1.10	2.06	3.84	7.16	10.3	13.4	16.3	22.1	27.7	30.5	35.9	41.3	46.5
	Type A			Type B					Type C				

For use of table see page 983.
*For lower or higher rpms see ANSI B29.1-1975.

Table 15 *(Continued).* **Horsepower Ratings for Roller Chain — 1975**

¾-inch Pitch Standard Single-Strand Roller Chain — No. 60

No. of Teeth Small Spkt.	Revolutions per Minute — Small Sprocket*												
	25	50	100	150	200	300	400	500	600	700	800	900	1000
	Horsepower Rating												
9	0.33	0.62	1.16	1.67	2.16	3.12	4.04	4.94	5.82	6.68	7.54	8.38	9.21
10	0.37	0.70	1.30	1.87	2.43	3.49	4.53	5.53	6.52	7.49	8.44	9.39	10.3
11	0.41	0.77	1.44	2.07	2.69	3.87	5.02	6.13	7.23	8.30	9.36	10.4	11.4
12	0.45	0.85	1.58	2.28	2.95	4.25	5.51	6.74	7.94	9.12	10.3	11.4	12.6
13	0.50	0.92	1.73	2.49	3.22	4.64	6.01	7.34	8.65	9.94	11.2	12.5	13.7
14	0.54	1.00	1.87	2.69	3.49	5.02	6.51	7.96	9.37	10.8	12.1	13.5	14.8
15	0.58	1.08	2.01	2.90	3.76	5.41	7.01	8.57	10.1	11.6	13.1	14.5	16.0
16	0.62	1.16	2.16	3.11	4.03	5.80	7.52	9.19	10.8	12.4	14.0	15.6	17.1
17	0.66	1.24	2.31	3.32	4.30	6.20	8.03	9.81	11.6	13.3	15.0	16.7	18.3
18	0.70	1.31	2.45	3.53	4.58	6.59	8.54	10.4	12.3	14.1	15.9	17.7	19.5
19	0.75	1.39	2.60	3.74	4.85	6.99	9.05	11.1	13.0	15.0	16.9	18.8	20.6
20	0.79	1.47	2.75	3.96	5.13	7.38	9.57	11.7	13.8	15.8	17.9	19.8	21.8
21	0.83	1.55	2.90	4.17	5.40	7.78	10.1	12.3	14.5	16.7	18.8	20.9	23.0
22	0.87	1.63	3.05	4.39	5.68	8.19	10.6	13.0	15.3	17.5	19.8	22.0	24.2
23	0.92	1.71	3.19	4.60	5.96	8.59	11.1	13.6	16.0	18.4	20.8	23.1	25.4
24	0.96	1.79	3.35	4.82	6.24	8.99	11.6	14.2	16.8	19.3	21.7	24.2	26.6
25	1.00	1.87	3.50	5.04	6.52	9.40	12.2	14.9	17.5	20.1	22.7	25.3	27.8
26	1.05	1.95	3.65	5.25	6.81	9.80	12.7	15.5	18.3	21.0	23.7	26.4	29.0
28	1.13	2.12	3.95	5.69	7.37	10.6	13.8	16.8	19.8	22.8	25.7	28.5	31.4
30	1.22	2.28	4.26	6.13	7.94	11.4	14.8	18.1	21.4	24.5	27.7	30.8	33.8
32	1.31	2.45	4.56	6.57	8.52	12.3	15.9	19.4	22.9	26.3	29.7	33.0	36.3
35	1.44	2.69	5.03	7.24	9.38	13.5	17.5	21.4	25.2	29.0	32.7	36.3	39.9
40	1.67	3.11	5.81	8.37	10.8	15.6	20.2	24.7	29.1	33.5	37.7	42.0	46.1
45	1.89	3.53	6.60	9.50	12.3	17.7	23.0	28.1	33.1	38.0	42.9	47.7	52.4
	Type A		Type B							Type C			

1-inch Pitch Standard Single-Strand Roller Chain — No. 80

No. of Teeth Small Spkt.	Revolutions per Minute — Small Sprocket*												
	25	50	100	150	200	300	400	500	600	700	800	900	1000
	Horsepower Rating												
9	0.78	1.45	2.71	3.90	5.05	7.28	9.43	11.5	13.6	15.6	17.6	17.0	14.5
10	0.87	1.63	3.03	4.37	5.66	8.16	10.6	12.9	15.2	17.5	19.7	19.9	17.0
11	0.97	1.80	3.36	4.84	6.28	9.04	11.7	14.3	16.9	19.4	21.9	23.0	19.6
12	1.06	1.98	3.69	5.32	6.89	9.93	12.9	15.7	18.5	21.3	24.0	26.2	22.3
13	1.16	2.16	4.03	5.80	7.52	10.8	14.0	17.1	20.2	23.2	26.2	29.1	25.2
14	1.25	2.34	4.36	6.29	8.14	11.7	15.2	18.6	21.9	25.1	28.4	31.5	28.2
15	1.35	2.52	4.70	6.77	8.77	12.6	16.4	20.0	23.6	27.1	30.6	34.0	31.2
16	1.45	2.70	5.04	7.26	9.41	13.5	17.6	21.5	25.3	29.0	32.8	36.4	34.4
17	1.55	2.88	5.38	7.75	10.0	14.5	18.7	22.9	27.0	31.0	35.0	38.9	37.7
18	1.64	3.07	5.72	8.25	10.7	15.4	19.9	24.4	28.7	33.0	37.2	41.4	41.1
19	1.74	3.25	6.07	8.74	11.3	16.3	21.1	25.8	30.4	35.0	39.4	43.8	44.5
20	1.84	3.44	6.41	9.24	12.0	17.2	22.3	27.3	32.2	37.0	41.7	46.3	48.1
21	1.94	3.62	6.76	9.74	12.6	18.2	23.5	28.8	33.9	39.0	43.9	48.9	51.7
22	2.04	3.81	7.11	10.2	13.3	19.1	24.8	30.3	35.7	41.0	46.2	51.4	55.5
23	2.14	4.00	7.46	10.7	13.9	20.1	26.0	31.8	37.4	43.0	48.5	53.9	59.3
24	2.24	4.19	7.81	11.3	14.6	21.0	27.2	33.2	39.2	45.0	50.8	56.4	62.0
25	2.34	4.37	8.16	11.8	15.2	21.9	28.4	34.7	40.9	47.0	53.0	59.0	64.8
26	2.45	4.56	8.52	12.3	15.9	22.9	29.7	36.2	42.7	49.1	55.3	61.5	67.6
28	2.65	4.94	9.23	13.3	17.2	24.8	32.1	39.3	46.3	53.2	59.9	66.7	73.3
30	2.85	5.33	9.94	14.3	18.5	26.7	34.6	42.3	49.9	57.3	64.6	71.8	78.9
32	3.06	5.71	10.7	15.3	19.9	28.6	37.1	45.4	53.5	61.4	69.2	77.0	84.6
35	3.37	6.29	11.7	16.9	21.9	31.6	40.9	50.0	58.9	67.6	76.3	84.8	93.3
40	3.89	7.27	13.6	19.5	25.3	36.4	47.2	57.7	68.0	78.1	88.1	99.0	108
45	4.42	8.25	15.4	22.2	28.7	41.4	53.6	65.6	77.2	88.7	100	111	122
	T'p A	Type B						Type C					

For use of table see page 983.
*For lower or higher rpms see ANSI B29.1-1975.

Table 15 *(Concluded).* **Horsepower Ratings for Roller Chain — 1975**

1¼-inch Pitch Standard Single-Strand Roller Chain — No. 100

No. of Teeth Small Spkt.	Revolutions per Minute — Small Sprocket*												
	10	25	50	100	150	200	300	400	500	600	700	800	900
	Horsepower Rating												
9	0.65	1.49	2.78	5.19	7.47	9.68	13.9	18.1	22.1	26.0	29.6	24.2	20.3
10	0.73	1.67	3.11	5.81	8.37	10.8	15.6	20.2	24.7	29.2	33.5	28.4	23.8
11	0.81	1.85	3.45	6.44	9.28	12.0	17.3	22.4	27.4	32.3	37.1	32.8	27.5
12	0.89	2.03	3.79	7.08	10.2	13.2	19.0	24.6	30.1	35.5	40.8	37.3	31.3
13	0.97	2.22	4.13	7.72	11.1	14.4	20.7	26.9	32.8	38.7	44.5	42.1	35.3
14	1.05	2.40	4.48	8.36	12.0	15.6	22.5	29.1	35.6	41.9	48.2	47.0	39.4
15	1.13	2.59	4.83	9.01	13.0	16.8	24.2	31.4	38.3	45.2	51.9	52.2	43.7
16	1.22	2.77	5.17	9.66	13.9	18.0	26.0	33.6	41.1	48.4	55.6	57.5	48.2
17	1.30	2.96	5.52	10.3	14.8	19.2	27.7	35.9	43.9	51.7	59.4	63.0	52.8
18	1.38	3.15	5.88	11.0	15.8	20.5	29.5	38.2	46.7	55.0	63.2	68.6	57.5
19	1.46	3.34	6.23	11.6	16.7	21.7	31.2	40.5	49.5	58.3	67.0	74.4	62.3
20	1.55	3.53	6.58	12.3	17.7	22.9	33.0	42.8	52.3	61.6	70.8	79.8	67.3
21	1.63	3.72	6.94	13.0	18.7	24.2	34.8	45.1	55.1	65.0	74.6	84.2	72.4
22	1.71	3.91	7.30	13.6	19.6	25.4	36.6	47.4	58.0	68.3	78.5	88.5	77.7
23	1.80	4.10	7.66	14.3	20.6	26.7	38.4	49.8	60.8	71.7	82.3	92.8	83.0
24	1.88	4.30	8.02	15.0	21.5	27.9	40.2	52.1	63.7	75.0	86.2	97.2	88.5
25	1.97	4.49	8.38	15.6	22.5	29.2	42.0	54.4	66.6	78.4	90.1	102	94.1
26	2.05	4.68	8.74	16.3	23.5	30.4	43.8	56.8	69.4	81.8	94.0	106	99.8
28	2.22	5.07	9.47	17.7	25.5	33.0	47.5	61.5	75.2	88.6	102	115	112
30	2.40	5.47	10.2	19.0	27.4	35.5	51.2	66.3	81.0	95.5	110	124	124
32	2.57	5.86	10.9	20.4	29.4	38.1	54.9	71.1	86.9	102	118	133	136
35	2.83	6.46	12.0	22.5	32.4	42.0	60.4	78.3	95.7	113	130	146	156
40	3.27	7.46	13.9	26.0	37.4	48.5	69.8	90.4	111	130	150	169	188
45	3.71	8.47	15.8	29.5	42.5	55.0	79.3	103	126	148	170	192	213
	Type A		Type B				Type C						

1½-inch Pitch Standard Single-Strand Roller Chain — No. 120

No. of Teeth Small Spkt.	Revolutions per Minute — Small Sprocket*												
	10	25	50	100	150	200	300	400	500	600	700	800	900
	Horsepower Rating												
9	1.10	2.52	4.69	8.76	12.6	16.3	23.5	30.5	37.3	43.2	34.3	28.1	23.5
10	1.24	2.82	5.26	9.81	14.1	18.3	26.4	34.2	41.8	49.2	40.1	32.9	27.5
11	1.37	3.12	5.83	10.9	15.7	20.3	29.2	37.9	46.3	54.6	46.3	37.9	31.8
12	1.50	3.43	6.40	11.9	17.2	22.3	32.1	41.6	50.9	59.9	52.8	43.2	36.2
13	1.64	3.74	6.98	13.0	18.8	24.3	35.0	45.4	55.5	65.3	59.5	48.7	40.8
14	1.78	4.05	7.56	14.1	20.3	26.3	37.9	49.1	60.1	70.8	66.5	54.4	45.6
15	1.91	4.37	8.15	15.2	21.9	28.4	40.9	53.0	64.7	76.3	73.8	60.4	50.6
16	2.05	4.68	8.74	16.3	23.5	30.4	43.8	56.8	69.4	81.8	81.3	66.5	55.7
17	2.19	5.00	9.33	17.4	25.1	32.5	46.8	60.6	74.1	87.3	89.0	72.8	61.0
18	2.33	5.32	9.92	18.5	26.7	34.6	49.8	64.5	78.8	92.9	97.0	79.4	66.5
19	2.47	5.64	10.5	19.6	28.3	36.6	52.8	68.4	83.6	98.5	105	86.1	72.1
20	2.61	5.96	11.1	20.7	29.9	38.7	55.8	72.2	88.3	104	114	92.9	77.9
21	2.75	6.28	11.7	21.9	31.5	40.8	58.8	76.2	93.1	110	122	100	83.8
22	2.90	6.60	12.3	23.0	33.1	42.9	61.8	80.1	97.9	115	131	107	89.9
23	3.04	6.93	12.9	24.1	34.8	45.0	64.9	84.0	103	121	139	115	96.1
24	3.18	7.25	13.5	25.3	36.4	47.1	67.9	88.0	108	127	146	122	102
25	3.32	7.58	14.1	26.4	38.0	49.3	71.0	91.9	112	132	152	130	109
26	3.47	7.91	14.8	27.5	39.7	51.4	74.0	95.9	117	138	159	138	115
28	3.76	8.57	16.0	29.8	43.0	55.7	80.2	104	127	150	172	154	129
30	4.05	9.23	17.2	32.1	46.3	60.0	86.4	112	137	161	185	171	143
32	4.34	9.90	18.5	34.5	49.6	64.3	92.6	120	147	173	199	188	158
35	4.78	10.9	20.3	38.0	54.7	70.9	102	132	162	190	219	215	180
40	5.52	12.6	23.5	43.9	63.2	81.8	118	153	187	220	253	...	...
45	6.27	14.3	26.7	49.8	71.7	92.9	134	173	212	250	287	...	...
	T'p A	Type B					Type C						

For use of table see page 983.
*For higher rpms and larger chain sizes see ANSI B29.1-1975.

Table 17–22

Tooth Correction Factors, K_1

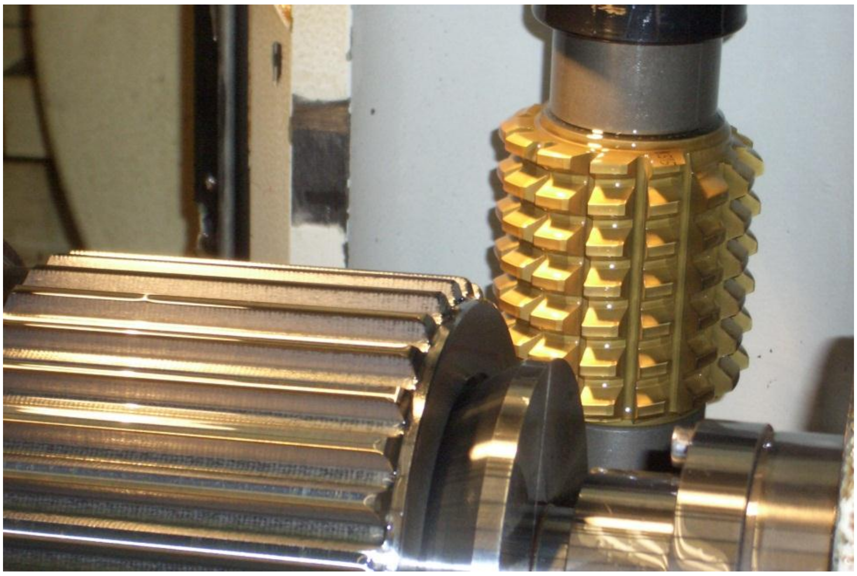
Number of Teeth on Driving Sprocket	K_1 Pre-extreme Power	K_1 Post-extreme Power
11	0.62	0.52
12	0.69	0.59
13	0.75	0.67
14	0.81	0.75
15	0.87	0.83
16	0.94	0.91
17	1.00	1.00
18	1.06	1.09
19	1.13	1.18
20	1.19	1.28
N	$(N_1/17)^{1.08}$	$(N_1/17)^{1.5}$

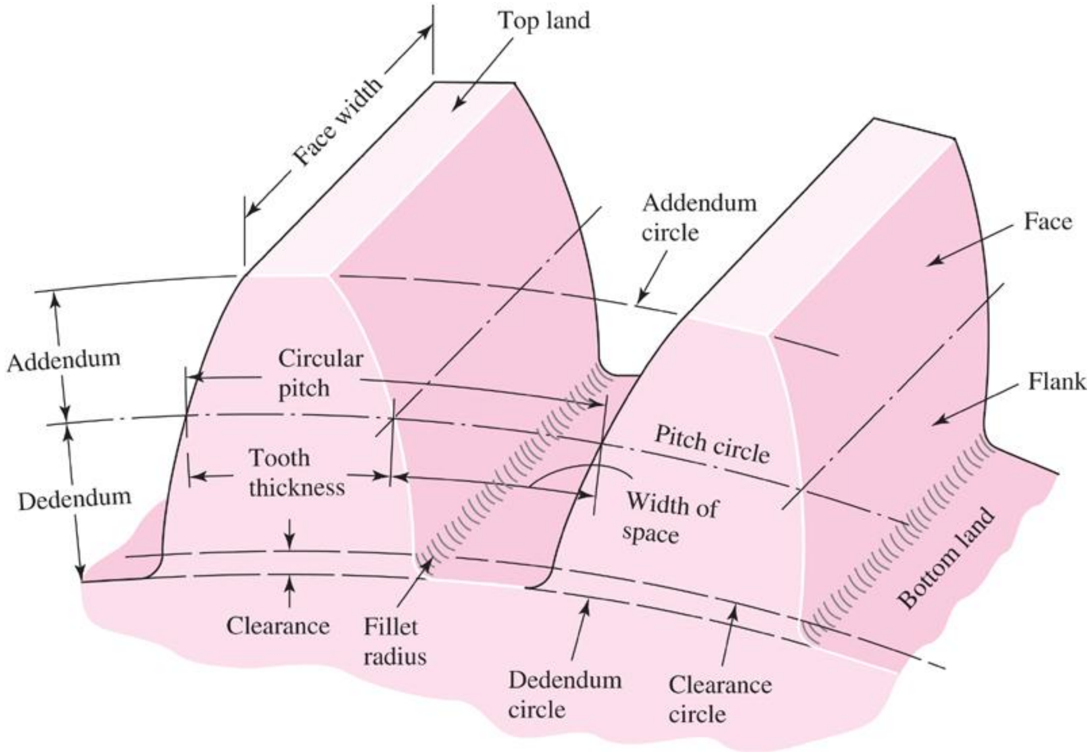
Table 17–23

Multiple-Strand Factors K_2

Number of Strands	K_2
1	1.0
2	1.7
3	2.5
4	3.3
5	3.9
6	4.6
8	6.0

٦- چرخ‌دنده ساده و هلیکال

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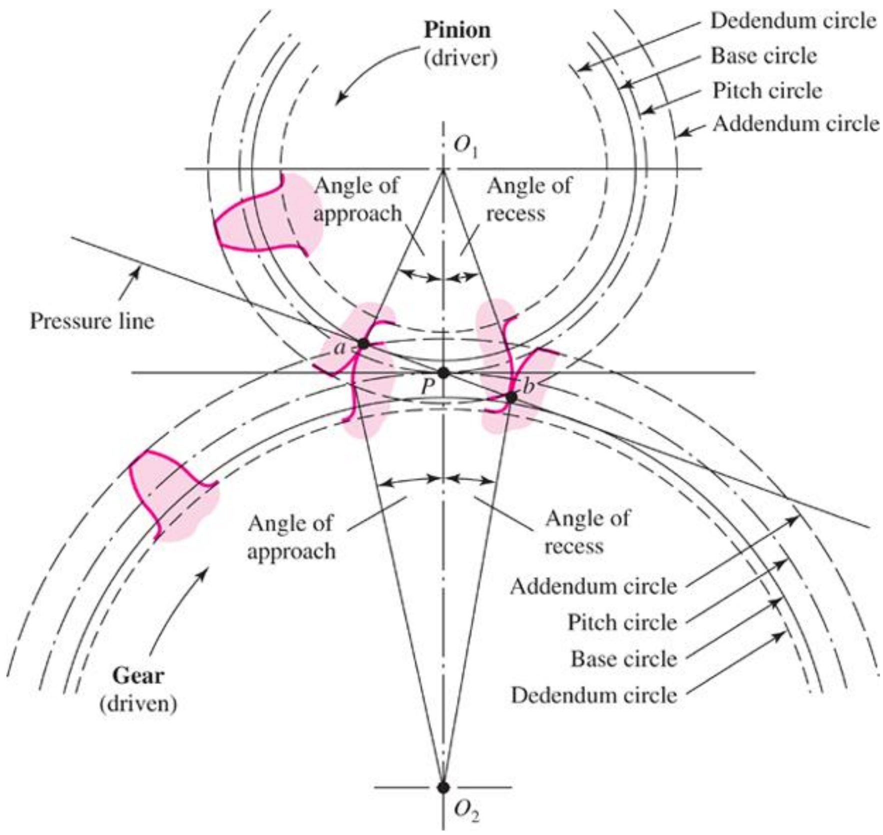
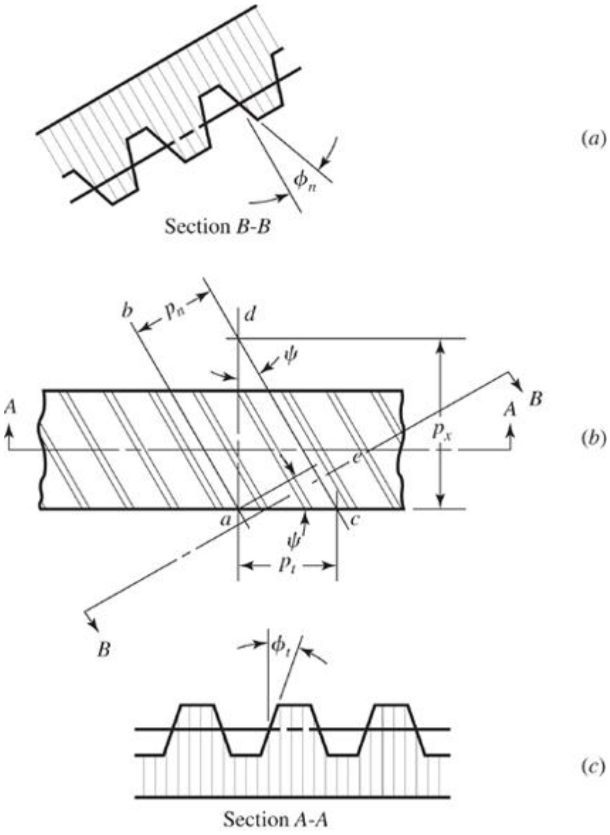
Face width
Addendum circle
Face
Addendum
Circular pitch
Flank
Pitch circle
Tooth thickness
Dedendum
Width of space
Bottom land
Clearance
Fillet radius
Dedendum circle
Clearance circle


Pinion
(driver)
Dedendum circle
Base circle
Pitch circle
Addendum circle
O_1
Angle of approach
Angle of recess
Pressure line
a
P
b
Angle of approach
Angle of recess
Addendum circle
Pitch circle
Base circle
Dedendum circle
Gear
(driven)
O_2

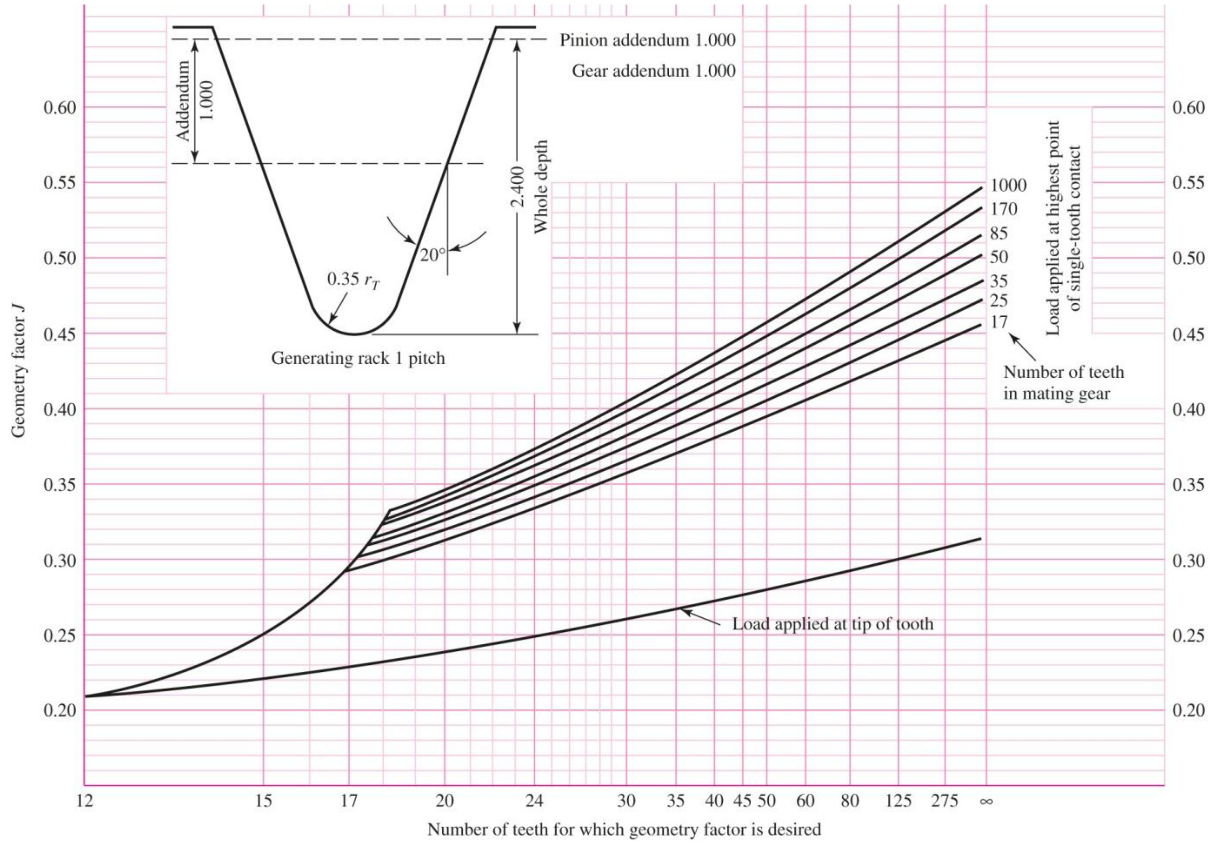


جدول مدول‌های استاندارد

۰/۱	۱	۴/۲۵ ❊	۱۱
۰/۲	۱/۲۵	۴/۵	۱۲
۰/۳	۱/۵	۴/۷۵ ❊	۱۳
۰/۴	۱/۷۵	۵	۱۴
۰/۵	۲	۵/۵	۱۵
.	.	.	.
.	.	.	.
.	.	.	.
۰/۸	۴	۱۰	۲۰

Table of Overload Factors, K_o

	Driven Machine		
Power source	Uniform	Moderate shock	Heavy shock
Uniform	1.00	1.25	1.75
Light shock	1.25	1.50	2.00
Medium shock	1.50	1.75	2.25



ضریب تصحیح اعتمادپذیری (C_R) برای تنش مجاز در رابطه سطحی

R	C_R
۰/۹۹	۰/۸
۰/۹۹ – ۰/۹۹۹	۱
بالاتر	۱/۲۵

ضریب تصحیح عمر (C_L) برای تنش مجاز در رابطه سطحی

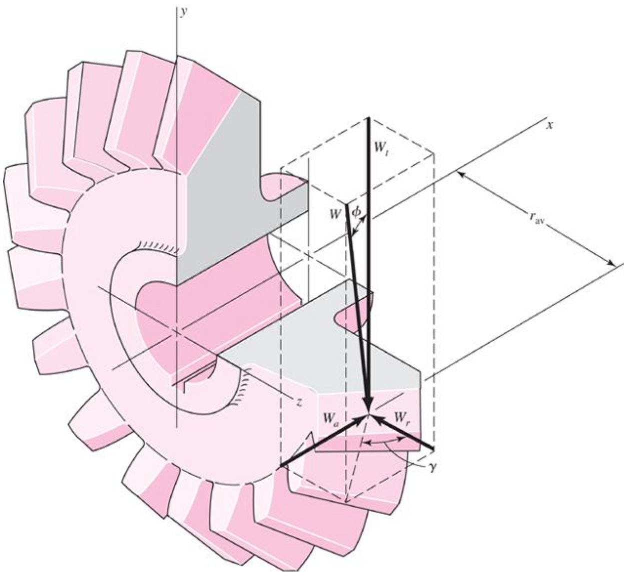
N	C_L
10^4	۱/۵
10^5	۱/۳
10^6	۱/۱
10^8	۱/۰

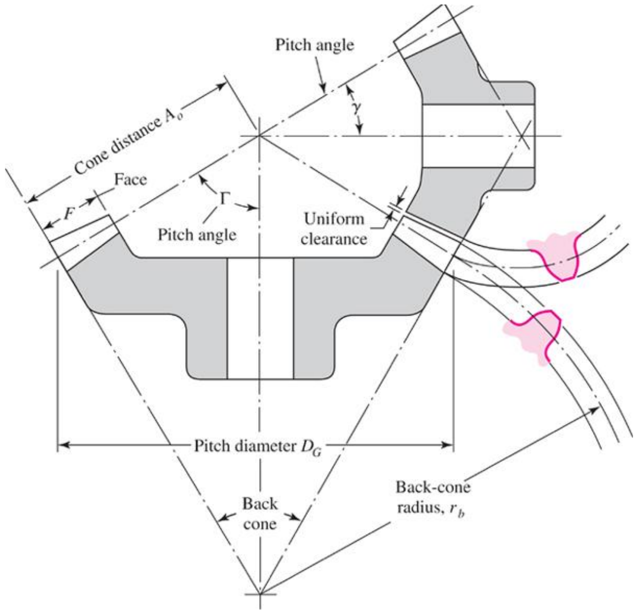
Table 14–8

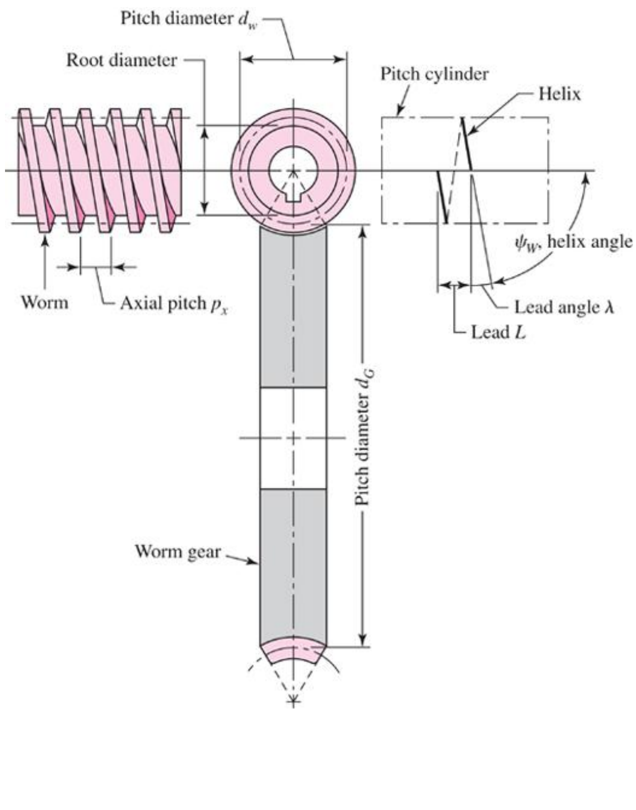
Elastic Coefficient C_p (Z_E), $\sqrt{\text{psi}}$ ($\sqrt{\text{MPa}}$) *Source: AGMA 218.01*

Pinion Material	Pinion Modulus of Elasticity E_p psi (MPa)*	Gear Material and Modulus of Elasticity E_G, lbf/in² (MPa)*: Steel 30×10^6 (2×10^5)	Malleable Iron 25×10^6 (1.7×10^5)	Nodular Iron 24×10^6 (1.7×10^5)	Cast Iron 22×10^6 (1.5×10^5)	Aluminum Bronze 17.5×10^6 (1.2×10^5)	Tin Bronze 16×10^6 (1.1×10^5)
Steel	30×10^6 (2×10^5)	2300 (191)	2180 (181)	2160 (179)	2100 (174)	1950 (162)	1900 (158)
Malleable iron	25×10^6 (1.7×10^5)	2180 (181)	2090 (174)	2070 (172)	2020 (168)	1900 (158)	1850 (154)
Nodular iron	24×10^6 (1.7×10^5)	2160 (179)	2070 (172)	2050 (170)	2000 (166)	1880 (156)	1830 (152)
Cast iron	22×10^6 (1.5×10^5)	2100 (174)	2020 (168)	2000 (166)	1960 (163)	1850 (154)	1800 (149)
Aluminum bronze	17.5×10^6 (1.2×10^5)	1950 (162)	1900 (158)	1880 (156)	1850 (154)	1750 (145)	1700 (141)
Tin bronze	16×10^6 (1.1×10^5)	1900 (158)	1850 (154)	1830 (152)	1800 (149)	1700 (141)	1650 (137)

۷- چرخ‌دنده حلزونی و مخروطی







Also, from Eq. (4),

$$\mathbf{F}_A = 10\mathbf{j} + 165\mathbf{k} \text{ lb}$$ *Ans.*

////

14-8 POWER RATING OF WORM GEARING

When worm gearsets are used intermittently or at slow gear speeds, the bending strength of the gear tooth may become a principal design factor. Since the worm teeth are inherently stronger than the gear teeth, they are usually not considered, though the methods of Chap. 8 can be used to compute worm-tooth stresses. The teeth of worm gears are thick and short at the two edges of the face and thin in the central plane, and this makes it difficult to determine the bending stress. Buckingham* adapts the Lewis equation as follows:

$$\sigma = \frac{W_{Gt}}{p_n F_G y} \qquad (14\text{-}28)$$

$$p_n = p_x \cos \lambda \qquad (14\text{-}29)$$

where σ = bending stress, psi
W_{Gt} = transmitted load, lb
p_n = normal circular pitch, in
p_x = axial circular pitch, in
F_G = face width of gear, in
y = Lewis form factor referred to the circular pitch
λ = lead angle

Since the equation is only a rough approximation, stress concentration is not considered. Also, for this reason, the form factors are not referred to the number of teeth, but only to the normal pressure angle. The values of y are listed in Table 14-4.

The AGMA equation for *input-horsepower rating* of worm gearing is

$$H = \frac{W_{Gt} d_G n_W}{126\,000 m_G} + \frac{V_s W_f}{33\,000} \qquad (14\text{-}30)$$

The first term on the right is the *output horsepower*, and the second is the *power loss*.

* Earle Buckingham, *Analytical Mechanics of Gears*, McGraw-Hill, New York, 1949, p. 495.

Table 14-4 VALUES OF y FOR WORM GEARS

Normal pressure angle ϕ_n, degrees	Form factor y
$14\frac{1}{2}$	0.100
20	0.125
25	0.150
30	0.175

The *permissible* transmitted load W_{Gt} is computed from the equation

$$W_{Gt} = K_s d_G^{0.8} F_e K_m K_v \tag{14-31}$$

The notation of Eqs. (14-30) and (14-31) is as follows:

W_{Gt} = transmitted load, lb
d_G = pitch diameter of gear, in
n_W = speed of worm, rpm
m_G = gear ratio, N_G/N_W
V_S = sliding velocity at mean worm diameter, fpm
W_f = frictional force, lb
K_s = materials and size-correction factor
F_e = effective face width of gear; the effective face width is the face width of the gear or two-thirds of the worm pitch diameter, whichever is less
K_m = ratio-correction factor
K_v = velocity factor

Table 14-5 MATERIALS FACTOR K_s FOR CYLINDRICAL WORM GEARING*

Face width of gear F_G, in	Sand-cast bronze	Static chill-cast bronze	Centrifugal-cast bronze
Up to 3	700	800	1000
4	665	780	975
5	640	760	940
6	600	720	900
7	570	680	850
8	530	640	800
9	500	600	750

* For copper-tin and copper-tin-nickel bronze gears operating with steel worms case-hardened to Rockwell 58C minimum.

Source: Darle W. Dudley (ed.), *Gear Handbook*, McGraw-Hill, New York, 1962, pp. 13-38.

Table 14-6 RATIO-CORRECTION FACTOR K_m

Ratio m_G	K_m	Ratio m_G	K_m	Ratio m_G	K_m
3.0	0.500	8.0	0.724	30.0	0.825
3.5	0.554	9.0	0.744	40.0	0.815
4.0	0.593	10.0	0.760	50.0	0.785
4.5	0.620	12.0	0.783	60.0	0.745
5.0	0.645	14.0	0.799	70.0	0.687
6.0	0.679	16.0	0.809	80.0	0.622
7.0	0.706	20.0	0.820	100.0	0.490

Source: Darle W. Dudley (ed.), *Gear Handbook*, McGraw-Hill, New York, 1962, pp. 13–38.

Values of the materials factor for hardened steel worms mating with bronze gears are listed in Table 14-5. Note the effect of the size-correction factor as the face width increases.

Values of the ratio-correction factor K_m and the velocity factor K_v are tabulated in Tables 14-6 and 14-7, respectively.

Example 14-6 A gear catalog lists a 4-pitch, $14\frac{1}{2}°$ pressure angle, single-thread, hardened steel worm to mate with a 24-tooth gear. The gear has a $1\frac{1}{2}$-in face width. Specifications for the worm are: lead, 0.7854 in; lead angle, 4.767°; face width, $4\frac{1}{2}$ in; pitch diameter, 3 in. The material of the gear is sand-cast bronze.

Table 14-7 VELOCITY FACTOR K_v

Velocity V_S, fpm	K_v	Velocity V_S, fpm	K_v	Velocity V_S, fpm	K_v
1	0.649	300	0.472	1400	0.216
1.5	0.647	350	0.446	1600	0.200
10	0.644	400	0.421	1800	0.187
20	0.638	450	0.398	2000	0.175
30	0.631	500	0.378	2200	0.165
40	0.625	550	0.358	2400	0.156
60	0.613	600	0.340	2600	0.148
80	0.600	700	0.310	2800	0.140
100	0.588	800	0.289	3000	0.134
150	0.558	900	0.269	4000	0.106
200	0.528	1000	0.258	5000	0.089
250	0.500	1200	0.235	6000	0.079

Source: Darle W. Dudley (ed.), *Gear Handbook*, McGraw-Hill, New York, 1962, pp. 13–39.

14-11 BEVEL GEARING—BENDING STRESS AND STRENGTH

In a typical bevel-gear mounting, Fig. 14-23 for example, one of the gears is often mounted outboard of the bearings. This means that shaft deflections can be more pronounced and have a greater effect on the contact of the teeth. Another difficulty which occurs in predicting the stress in bevel-gear teeth is the fact that the teeth are tapered. Thus, to achieve perfect line contact passing through the cone center, the teeth ought to bend more at the large end than at the small end. To obtain this condition requires that the load be proportionately greater at the large end. Because of this varying load across the face of the teeth, it is desirable to have a fairly short face width.

The equation for bending stress in spur gears is used for bevel gears, too, and is repeated here for convenience.

$$\sigma = \frac{W_t P}{K_v F J} \tag{14-37}$$

where all relations are based on the large end of the teeth.

Caution: The transmitted load W_t must be computed using the pitch radius at the large end of the teeth in Eq. (14-37). Note that this is not the same transmitted load used in force analysis (Sec. 14-10), though the symbol is the same.

The geometry factor J is different for bevel gears because the long-and-short addendum system is used and because the teeth are tapered. Use Fig. 14-25.

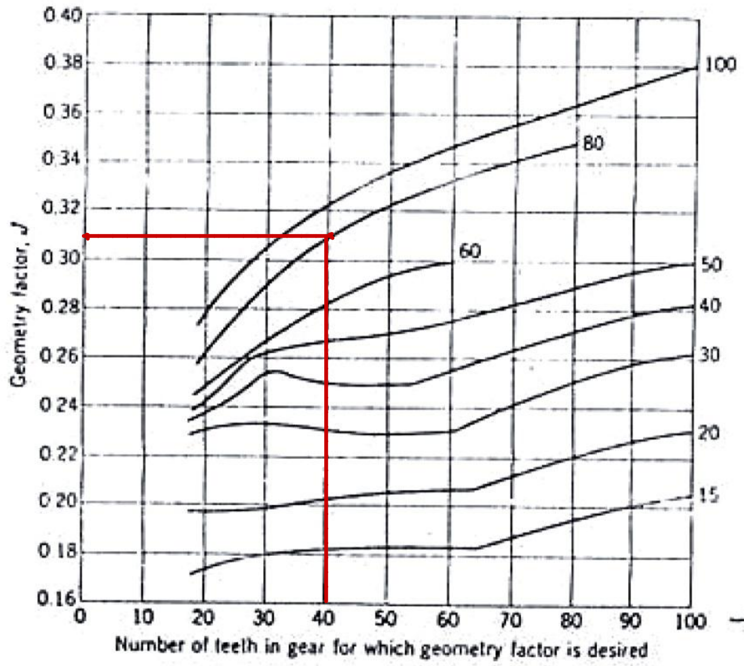


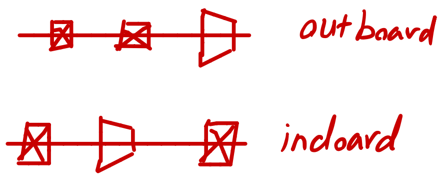
FIGURE 14-25 Geometry factors J for straight bevel gears; these are for a 90° shaft angle, 20° pressure angle, and a clearance of $c = 0.240/P$ in. (*AGMA Information Sheet 225.01.*)

Table 14-9 APPROXIMATE BEVEL-GEAR LOAD DISTRIBUTION FACTORS K_m AND C_m

$(FS)_c = K_m K_o (FS)_{net}$

Application	Both gears inboard	One gear outboard	Both gears outboard
General industrial	1.00–1.10	1.10–1.25	1.25–1.40
Automotive	1.00–1.10	1.10–1.25	
Aircraft	1.00–1.25	1.10–1.40	1.25–1.50

Source: *AGMA Information Sheet* 225.01, 1967, table 4.



The modification and correction factors for bevel gears are the same as for spur gears except for the load-distribution factor K_m (Table 14-9).*

14-12 BEVEL GEARING—SURFACE DURABILITY

The Hertzian contact stress for bevel gears is given by the equation

$$\sigma_H = -C_p \sqrt{\frac{W_t}{C_v F d_p I}} \qquad (14\text{-}38)$$

where, again, all values correspond to the large end of the teeth.

Since the contact of bevel-gear teeth tends to be localized, the elastic coefficient C_p must be based on a Hertzian analysis of contacting spheres rather than cylinders. This yields slightly different values. Thus, use Table 14-10.

Figure 14-26 is a chart of the geometry factor I for bevel gears. All other factors may be obtained using the methods of Chap. 13.

Example 14-8 A pair of miter gears listed in a catalog have a diametral pitch of 5, 25 teeth, 1.10 in face width, a 20° pressure angle, and are made of a 0.20 plain-carbon steel with the teeth case-hardened. In this example it is assumed that the case hardness is 500 Bhn. The gears are intended for general industrial use, and it is quite likely that applications will occur in which both gears must have outboard mountings.

(*a*) Specify a horsepower rating based on bending strength using a factor of safety of 1.8 and a speed of 600 rpm.
(*b*) The same as (*a*), based on surface durability and a factor of safety of 1.20.

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* The AGMA uses a different size factor for bevel gears than for others. However, they compensate for this by recommending a different set of allowable stresses. See *AGMA Information Sheet* 225.01, 1967.

Table 14-10 VALUES OF THE ELASTIC COEFFICIENT C_p FOR BEVEL GEARS AND OTHERS WITH LOCALIZED CONTACT*

	Gear			
Pinion	Steel	Cast iron	Aluminum bronze	Tin bronze
Steel, $E = 30$	2800	2450	2400	2350
Cast iron, $E = 19$	2450	2250	2200	2150
Aluminum bronze, $E = 17.5$	2400	2200	2150	2100
Tin bronze, $E = 16$	2350	2150	2100	2050

Source: *AGMA Information Sheet* 212.02

* In each case the modulus of elasticity is in Mpsi.

Solution (*a*) The pitch diameter at the large end of the teeth is $d = \frac{25}{5} = 5$ in. Since the face width is 1.10 in. and the pitch angle of a miter gear is 45°, the average pitch diameter is

$$d_{av} = d - F \sin \gamma = 5 - 1.10 \sin 45° = 4.22 \text{ in}$$

The pitch-line velocity at the average diameter is

$$V = \frac{\pi d_{av} n}{12} = \frac{\pi(4.22)(600)}{12} = 663 \text{ fpm}$$

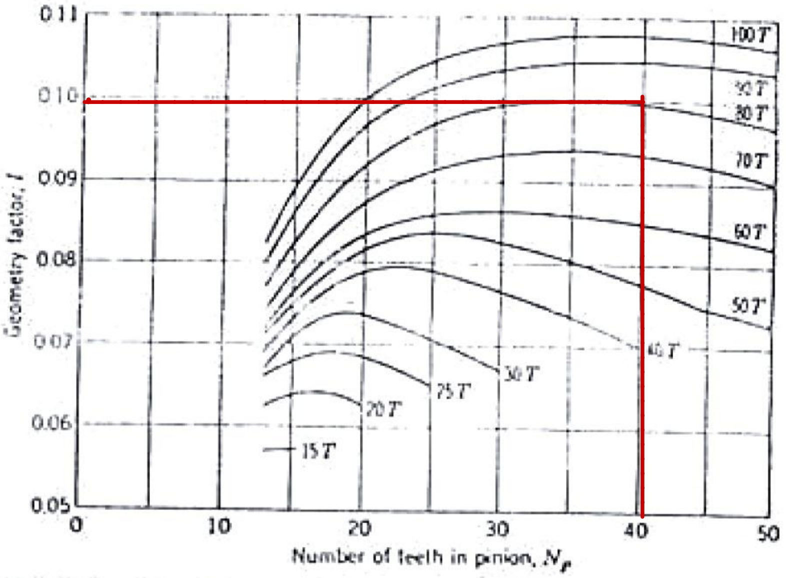


FIGURE 14-26 Geometry factors I for straight bevel gears of 20° pressure angle mounted at a 90° shaft angle. (*AGMA Information Sheet 212.02.*)

است، وبنابراین تنش خمشی برابراست با

$$\sigma=\frac{M}{I/c}=\frac{6W_tl}{Ft^2} \qquad \text{(الف)}$$

حال بامراجعه به‌شکل۱۳–۲۲ ب فرض‌می‌کنیم تنش‌بیشینه دریك دندانهٔ چرخدنده درنقطهٔ a رخ می‌دهد. باتشابه مثلثها، می‌توانید بنویسید

$$\frac{t/2}{x}=\frac{l}{t/2} \quad \text{یا} \quad x=\frac{t^2}{4l} \qquad \text{(ب)}$$

با بازآرایی معادلهٔ (الف)،

$$\sigma=\frac{6W_tl}{Ft^2}=\frac{W_t}{F}\,\frac{1}{t^2/6l}=\frac{W_t}{F}\,\frac{1}{t^2/4l}\,\frac{1}{\frac{4}{6}} \qquad \text{(ج)}$$

حال اگرمقدار x را ازمعادلهٔ (ب) درمعادلهٔ (ج) قرار دهیم وصورت ومخرج را درگام دایره‌ای p ضرب‌کنیم، داریم

$$\sigma=\frac{W_tp}{F\left(\frac{2}{3}\right)xp} \qquad \text{(د)}$$

با قراردادن $y=2x/3p$، داریم

$$\sigma=\frac{W_t}{Fpy} \qquad (۱۳–۱۶)$$

این معادلهٔ اصلی لوئیس است. ضریب y، ضریب شکل لوئیس نامیده می‌شود، ومی‌توان با ترسیم دندانهٔ چرخدنده یا با محاسبهٔ عددی آن‌را به‌دست آورد.

دراستفاده ازاین معادلـه، بیشتر طراحان ترجیح مـی‌دهند در تعیین تنش از مدول استفاده‌کنند. این‌کار باقراردادن $m=p/\pi$ و $Y=\pi y$ درمعادلهٔ (۱۳–۱۶) میسرمی‌شود. نتیجه چنین است

$$\sigma=\frac{W_t}{FmY} \qquad (۱۳–۱۷)$$

دراستفاده از این معادله پیشنهاد می‌شودکه W_t به‌نیوتون و F و m به میلیمتر باشند. پس نتیجه، σ بـرحسب MPa خواهد بود. برای دیدن مقدارهای Y به‌جدول ۱۳–۳ رجوع کنید.

جدول ۱۳–۳ مقدارهای ضریب شکل لوئیس Y

تعداد دندانه	$\phi=20°$, $a=0.8m$*, $b=m$	$\phi=20°$, $a=m$, $b=1.25m$	$\phi=25°$, $a=m$, $b=1.25m$	$\phi=25°$, $a=m$, $b=1.35m$ **
12	0.335 12	0.229 60	0.276 77	0.254 73
13	0.348 27	0.243 17	0.292 81	0.271 77
14	0.359 85	0.255 30	0.307 17	0.287 11
15	0.370 13	0.266 22	0.320 09	0.301 00
16	0.379 31	0.276 10	0.331 78	0.313 63
17	0.387 57	0.285 08	0.342 40	0.325 17
18	0.395 02	0.293 27	0.352 10	0.335 74
19	0.401 79	0.300 78	0.360 99	0.345 46
20	0.407 97	0.307 69	0.369 16	0.354 44
21	0.413 63	0.314 06	0.376 71	0.362 76
22	0.418 83	0.319 97	0.383 70	0.370 48
24	0.428 06	0.330 56	0.396 24	0.384 39
26	0.436 01	0.339 79	0.407 17	0.396 57
28	0.442 94	0.347 90	0.416 78	0.407 33
30	0.449 02	0.355 10	0.425 30	0.416 91
34	0.459 20	0.367 31	0.439 76	0.433 23
38	0.467 40	0.377 27	0.451 56	0.446 63
45	0.478 46	0.390 93	0.467 74	0.465 11
50	0.484 58	0.398 60	0.476 81	0.475 55
60	0.493 91	0.410 47	0.490 86	0.491 77
75	0.503 45	0.422 83	0.505 46	0.508 77
100	0.513 21	0.435 74	0.520 71	0.526 65
150	0.523 21	0.449 30	0.536 68	0.545 56
300	0.533 48	0.463 64	0.553 51	0.565 70
شانه‌ای	0.544 06	0.478 97	0.571 39	0.587 39

* دندانه‌های کوتاه

** قوس بزرگ

استفاده ازاین ضریب شکل اصلی لـوئیس به این معناست‌کـه دندانه‌ها بار را به اشتراك‌حمل نمی‌کنند وبیشترین نیرو به‌بالای دندانه اعمال می‌شود. ولی ازقبل آموخته‌ایم که نسبت تماس می‌بایست قدری بیشتر از یك باشد، مثلا درحدود ۱٫۵، تـا به‌مجموعـهٔ چرخدنده‌ای مرغوب دست یافت. درحقیقت اگرچرخدنده‌ها بادقت‌کافی تـراشیده شوند، حالت بارگذاری تاج دندانه بدترین وضعیت بارگذاری نیست زیرا دراین حالت جفت دیگری از دندانه‌ها درتماس خواهند بود. بررسی دندانه‌های درحرکت نشان خواهد داد که سنگینترین بارها در نزدیکی وسط دندانه رخ می‌دهند. بنابراین بیشترین تنش احتمالا درحالتی که یك‌جفت دندانه تمامی بار را حمل می‌کنند پدید می‌آید واین‌درلحظه‌ای‌است

$$L = 0.316 - 0.2583662\,\phi \qquad \text{(ب)}$$

$$M = 0.290 + 0.2583662\,\phi \qquad \text{(ج)}$$

$$r = \frac{r_f + (b - r_f)^2}{(d/2) + b - r_f} \qquad \text{(د)}$$

دراین معادله‌ها l و t از رسم شکل ۱۳-۲۲ به‌دست می‌آیند، ϕ زاویهٔ فشار، و r_f شعاع قوس است، b دیدندوم، و d قطر گام است.

ضریب هندسی

AGMA ضریب J را تعریف کرده‌است که ضریب هندسی نامیده می‌شود و از ضریب شکل اصلاح شدهٔ Y ازمعادلهٔ (۱۳-۱۸)، ضریب‌تمرکز تنش خستگی K_f ازمعادلهٔ (۱۳-۱۹)، و نسبت اشتراك بار m_N استفاده می‌کند؛ نسبت اشتراك بار بر مقدارکل باری‌که توسط دندانهٔ با سنگینترین بارگذاری حمل می‌شود مبتنی است. معادلهٔ AGMA چنین است

$$J = \frac{Y}{K_f m_N} \qquad (۱۳\text{-}۲۰)$$

چون مقدار Y درمعادلهٔ (۱۳-۲۰) برمبنای بالاترین نقطهٔ تماس یك جفت دندانه حساب می‌شود، $m_N = 1$، و برای چرخدنده‌های ساده، معادلهٔ (۱۳-۲۰) به صورت زیرنوشته می‌شود

$$J = \frac{Y}{K_f} \qquad (۱۳\text{-}۲۱)$$

دراین جا تأکید می‌کنیم‌که Y در معادلهٔ (۱۳-۲۱) مقداری است کـه توسط معادلهٔ (۱۳-۱۸) به‌دست می‌آید ومشابه به مقدارهای جدول ۱۳-۳ نیست.

حال، بااین تعریف ضریب هندسی، می‌توانیم معادلهٔ (۱۳-۱۷) را بهشکل زیـر بنویسیم

$$\sigma = \frac{W}{FmJ} \qquad (۱۳\text{-}۲۲)$$

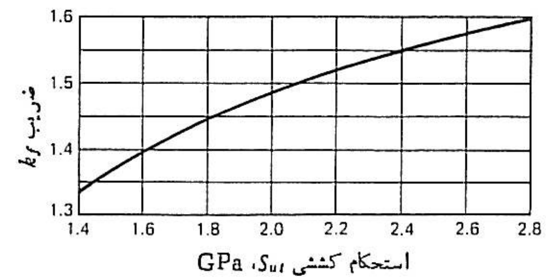
که تنش عمودی مربوط به‌کل بار اعمالی w در بالاترین نقطهٔ تماس یك‌جفت دندانه را می‌دهد وشامل اثرهای تمرکز تنش‌است. مقدارهای ضریب هندسی J درجدولهای ۱۳-۴ و۱۳-۵ برای دندانه‌های °۲۰ و°۲۵ داده شده‌است. این‌جدولها از مقالهٔ میچینر و میبی برگرفته شده‌اندکه داده‌هایی برای سایر دندانه‌ها را نیزشامل می‌شود.

جدول ۱۳ [illegible] ضریب هندسی AGMA، J برای دندانه‌های با $\phi = 20^\circ$، $a = 1m$، $b = 1.25m$ و $r_f = 0.300m$

تعداد دندانه‌ها	تعداد دندانه‌های چرخدندهٔ درگیر							
	1	17	25	35	50	85	300	1000
18	0.244 86	0.324 04	0.332 14	0.338 40	0.344 04	0.350 50	0.355 94	0.361 12
19	0.247 94	0.330 29	0.338 78	0.345 37	0.351 34	0.358 22	0.364 05	0.369 63
20	0.250 72	0.336 00	0.344 85	0.351 76	0.358 04	0.365 32	0.371 51	0.377 49
21	0.253 23	0.341 24	0.350 44	0.357 64	0.364 22	0.371 86	0.378 41	0.384 75
22	0.255 52	0.346 07	0.355 59	0.363 06	0.369 92	0.377 92	0.384 79	0.391 48
24	0.259 51	0.354 68	0.364 77	0.372 75	0.380 12	0.388 77	0.396 26	0.403 60
26	0.262 89	0.362 11	0.372 72	0.381 15	0.388 97	0.398 21	0.406 25	0.414 18
28	0.265 80	0.368 60	0.379 67	0.388 51	0.396 73	0.406 50	0.415 04	0.423 51
30	0.268 31	0.374 62	0.385 80	0.395 00	0.403 59	0.413 83	0.422 83	0.431 79
34	0.272 47	0.383 94	0.396 71	0.405 94	0.415 17	0.426 24	0.436 04	0.445 86
38	0.275 75	0.391 70	0.404 46	0.414 80	0.424 56	0.436 33	0.446 80	0.457 35
45	0.280 13	0.402 23	0.415 79	0.426 85	0.437 35	0.450 10	0.461 52	0.473 10
50	0.282 52	0.408 08	0.422 08	0.435 55	0.444 48	0.457 78	0.469 75	0.481 93
60	0.286 13	0.417 02	0.431 73	0.443 83	0.455 42	0.469 60	0.482 43	0.495 57
75	0.289 79	0.426 20	0.441 63	0.454 40	0.466 68	0.481 79	0.495 54	0.509 70
100	0.293 53	0.435 61	0.451 80	0.465 27	0.478 27	0.494 37	0.509 09	0.524 35
150	0.297 38	0.445 30	0.462 26	0.476 45	0.490 23	0.507 36	0.523 12	0.539 54
300	0.301 41	0.455 26	0.473 04	0.487 98	0.502 56	0.520 78	0.537 65	0.555 33
شانه‌ای	0.305 71	0.465 54	0.484 15	0.499 88	0.515 29	0.534 67	0.552 72	0.571 73

جدول ۱۳-۵ ضریب هندسی AGMA، J برای دندانه‌های با $\phi = 25^\circ$، $a = 1m$، $b = 1.25m$، و $r_f = 0.300m$

تعداد دندانه‌ها	تعداد دندانه‌های چرخدندهٔ درگیر							
	1	17	25	35	50	85	300	1000
13	0.286 65	0.346 84	0.352 92	0.357 44	0.361 38	0.365 72	0.369 25	0.372 51
14	0.293 64	0.359 24	0.365 87	0.370 81	0.375 14	0.379 94	0.383 86	0.387 49
15	0.300 09	0.370 27	0.377 40	0.382 75	0.387 44	0.392 67	0.396 94	0.400 92
16	0.305 58	0.380 16	0.387 75	0.393 46	0.398 49	0.404 11	0.408 73	0.413 03
17	0.310 43	0.389 07	0.397 09	0.403 14	0.408 49	0.414 48	0.419 41	0.424 02
18	0.314 75	0.397 14	0.405 56	0.411 93	0.417 56	0.423 90	0.429 13	0.434 03
19	0.318 62	0.404 49	0.413 28	0.419 94	0.425 85	0.432 50	0.438 01	0.443 18
20	0.322 11	0.411 21	0.420 34	0.427 27	0.433 44	0.440 39	0.446 16	0.451 59
21	0.325 28	0.417 38	0.426 82	0.434 01	0.440 42	0.447 65	0.453 67	0.459 33
22	0.328 16	0.423 06	0.432 80	0.440 23	0.446 86	0.454 36	0.460 60	0.466 50
24	0.333 22	0.433 18	0.443 46	0.451 32	0.458 36	0.466 35	0.473 01	0.479 32
26	0.337 52	0.441 93	0.452 68	0.460 93	0.468 33	0.476 74	0.483 78	0.490 46
28	0.341 22	0.449 57	0.460 75	0.469 33	0.477 05	0.485 85	0.493 23	0.500 23
30	0.344 43	0.456 31	0.467 85	0.476 75	0.484 75	0.493 89	0.501 57	0.508 68
34	0.349 76	0.467 63	0.479 81	0.489 23	0.497 72	0.507 46	0.515 66	0.523 49
38	0.354 00	0.476 78	0.489 48	0.499 33	0.508 24	0.518 47	0.527 10	0.535 36
45	0.359 67	0.489 19	0.502 61	0.513 05	0.522 52	0.533 44	0.542 68	0.551 54
50	0.362 78	0.496 08	0.509 91	0.520 68	0.530 47	0.541 77	0.551 36	0.560 56
60	0.367 50	0.506 83	0.521 09	0.532 38	0.542 67	0.554 57	0.564 69	0.574 44
75	0.372 32	0.517 47	0.532 57	0.544 40	0.555 20	0.567 73	0.578 42	0.588 73
100	0.377 26	0.528 60	0.544 36	0.556 76	0.568 10	0.581 29	0.592 57	0.603 48
150	0.382 37	0.540 05	0.556 51	0.569 51	0.581 38	0.595 26	0.607 16	0.618 69
300	0.387 72	0.551 85	0.569 02	0.582 59	0.595 07	0.609 67	0.622 22	0.634 42
شانه‌ای	0.393 42	0.564 05	0.581 94	0.596 13	0.609 21	0.624 56	0.637 78	0.650 68



شکل ۱۳-۲۶ ضریبهای اثرهای گوناگون برای خمش یک‌طرفهٔ دندانه‌های چرخدنده. از $k_f=1.33$ برای مقدارهای S_{ut} کمتر از ۱٫۴ GPa استفاده کنید.

خستگی تکرار می‌شود ولی معکوس‌شونده نیست و بنابراین گفته می‌شود که دندانه تحت خمش یک‌طرفه است. برای این وضعیت، مؤلفه‌های تنش میانگین و متناوب عبارت‌اند از

$$\sigma_a=\sigma_m=\frac{\sigma}{2} \qquad \text{(د)}$$

که σ تنش خمشی دندانه است که ازمعادلهٔ (۱۳-۲۸) به‌دست می‌آید. معنی این امر آن است که هنگامی می‌توانیم ضریب اثرهای گوناگون را برای افزایش حد دوام دندانه به‌کار گیریم که دندانه فقط تحت خمش یک‌طرفه قرار گرفته باشد. با قراردادن مقدارهای معادلهٔ (د) درمعادلهٔ (۷-۳۲) برای خط اصلاح شدهٔ گودمن، داریم

$$\sigma=\frac{2S_eS_{ut}}{S_{ut}+S_e} \qquad (۱۳-۳۱)$$

درفصل ۷ آموختیم که $S'_e=0.5S_{ut}$ هنگامی که $S_{ut}\leqslant 1400$ MPa. با قرار دادن $S_{ut}=S'_e/0.5$ درمعادلهٔ (۱۳-۳۱) پیدا می‌کنیم که $\sigma=1.33S'_e$. بنابراین هنگامی که $S_{ut}\leqslant 1400$ MPa، $k_f=1.33$. از معادلهٔ (۱۳-۳۱) می‌توان برای پیداکردن سایر مقدارهای k_f هنگامی که $S_{ut}>1400$ MPa باشد استفاده کرد. این مقدار محاسبه و دراینجا به‌عنوان شکل ۱۳-۲۶ ارائه شده‌است.

البته، برای خمش دوطرفه، $k_f=1.00$.

۱۳-۱۵ ضریب ایمنی

از فرمول

$$n_G=K_oK_mn \qquad (۱۳-۳۲)$$

جدول ۱۳-۹ ضریب تصحیح اضافه‌بار K_o

منبع قدرت	ماشین رانده شده: یکنواخت	شوک متوسط	شوک سنگین
یکنواخت	۱٫۰۰	۱٫۲۵	۱٫۷۵
شوک سبک	۱٫۲۵	۱٫۵۰	۲٫۰۰
شوک متوسط	۱٫۵۰	۱٫۷۵	۲٫۲۵

می‌توان برای محاسبهٔ ضریب ایمنی چرخدنده‌ها استفاده کرد. دراین فرمول K_o ضریب اضافه بار است. مقدارهایی که توسط AGMA پیشنهاد شده درجدول ۱۳-۹ فهرست شده‌اند. ضریب K_m ضریب توزیع بار AGMA است که برای به حساب آوردن احتمال توزیع نایکنواخت نیروی دندانه بر پهنای رویه درنظر گرفته می‌شود. برای یافتن K_m از جدول ۱۳-۱۰ استفاده کنید. ضریب n در معادلهٔ (۱۳-۳۲) ضریب ایمنی معمول است که در فصل ۱ تعریف شد. AGMA برای مقابله با شکست خستگی استفاده از $n\geqslant 2$ را توصیه می‌کند.

جدول ۱۳-۱۰ ضریب توزیع بار K_m برای چرخدنده‌های ساده

مشخصه‌های تکیه‌گاه	پهنای رویه، mm: ۰ تا ۵۰	۱۵۰	۲۲۵	۴۰۰ به بالا
نصبهای دقیق، آزادی کم یاتاقان، خیز کمینه، چرخدنده‌های دقیق	۱٫۳	۱٫۴	۱٫۵	۱٫۸
نصبهای کمتر صلب، چرخدنده‌های کم دقت‌تر، تماس درتمام طول رویه	۱٫۶	۱٫۷	۱٫۸	۲٫۲
دقت در نصب به‌قسمی که تماس کمتر از تمام رویه وجود داشته باشد	بیش‌از ۲٫۲			

$$b=\sqrt{\frac{2F}{\pi l}\frac{[(1-\nu_1^2)/E_1]+[(1-\nu_2^2)/E_2]}{(1/d_1)+(1/d_2)}} \qquad (۱۳-۳۴)$$

که ν_1، ν_2، E_1 و E_2 ثابتهای کشسانی و d_1 و d_2 به‌ترتیب قطرهای دواستوانه‌اند. برای وفق دادن این رابطه‌ها با نمادگذاری مورد استفاده درچرخدنده، F را با $W_t/\cos\phi$، d را با $2r$، و l را با پهنای رویهٔ F جایگزین می‌کنیم. با این تغییرها می‌توانیم مقدار b را ازمعادلهٔ (۱۳-۳۴) درمعادلهٔ (۱۳-۳۳) بگذاریم. باعوض‌کردن p_{max} با σ_H، تنش فشاری سطح (تنش هرتز) به‌صورت زیر پیدا می‌شود

$$\sigma_H^2=\frac{W_t}{F\cos\phi}\frac{(1/r_1)+(1/r_2)}{[(1-\nu_1^2)/E_1]+[(1-\nu_2^2)/E_2]} \qquad (۱۳-۳۵)$$

که r_1 و r_2 به‌ترتیب مقدارهای لحظه‌ای شعاعهای انحنای پروفیلهای دندانهٔ پینیون و چرخدنده درنقطهٔ تماس‌اند. با به‌حساب آوردن اشتراک بار درمقدار W_t استفاده شده، معادلهٔ (۱۳-۳۵) رامی‌توان برای یافتن تنش هرتز درهرنقطه یا همهٔ نقطه‌ها، ازآغاز تا پایان تماس دندانه حل کرد. البته، غلتش خالص‌فقط درنقطهٔ گام وجود دارد. جای دیگر، ترکیبی ازحرکت غلتشی ولغزشی دیده می‌شود. معادلهٔ (۱۳-۳۵) هیچ‌عمل لغزشی را در براورد تنش منظور نمی‌کند.

به‌عنوان‌مثالی برای استفاده ازاین‌معادله، تنش‌تماسی را، هنگامی که یک‌جفت دندانه درنقطهٔ گام درتماس‌اند، پیدا می‌کنیم. شعاعهای انحنای r_1 و r_2 پروفیلهای دندانه هنگام تماس درنقطهٔ‌گام عبارت‌اند از

$$r_1=\frac{d_P\sin\phi}{2}\qquad r_2=\frac{d_G\sin\phi}{2} \qquad (الف)$$

که ϕ زاویهٔ فشاراست. درنتیجه

$$\frac{1}{r_1}+\frac{1}{r_2}=\frac{2}{\sin\phi}\left(\frac{1}{d_P}+\frac{1}{d_G}\right) \qquad (ب)$$

با تعریف نسبت سرعت m_G به‌صورت زیر

$$m_G=\frac{N_G}{N_P}=\frac{d_G}{d_P} \qquad (۱۳-۳۶)$$

می‌توانیم معادلهٔ (ب) را به‌صورت زیر بنویسیم

$$\frac{1}{r_1}+\frac{1}{r_2}=\frac{2}{\sin\phi}\,\frac{m_G+1}{m_G d_P} \qquad (ج)$$

پس‌از بازآرایی واستفاده ازمعادلهٔ (ج)، معادلهٔ (۱۳-۳۵) به‌صورت زیر درمی‌آید

(۱۳-۳۷)

$$\sigma_H=-\sqrt{\frac{W_t}{Fd_P}\,\frac{1}{\pi\left(\frac{1-\nu_P^2}{E_P}+\frac{1-\nu_G^2}{E_G}\right)}\,\frac{1}{\frac{\cos\phi\sin\phi}{2}\,\frac{m_G}{m_G+1}}}$$

علامت منفی مشخص می‌کندکه σ_H فشاری‌است. زیرنمادهای P و G درمعادلهٔ (۱۳-۳۷) که درمورد ν و E به‌کار رفته‌اند به‌ترتیب به‌پینیون وچرخدنده مربوط می‌شود.

دومین عبارت زیر رادیکال معادلهٔ (۱۳-۳۷)، ضریب کشسان C_P نامیده می‌شود. لذا، فرمول C_P

$$C_P=\sqrt{\frac{1}{\pi\left(\frac{1-\nu_P^2}{E_P}+\frac{1-\nu_G^2}{E_G}\right)}} \qquad (۱۳-۳۸)$$

است. مقدارهای C_P برای ترکیبهای مختلفی ازمواد به دست آمده و درجدول ۱۳-۱۱ فهرست شده‌است.

جدول ۱۳-۱۱ مقدارهای‌ضریب‌کشسان C_P برای چرخدنده‌های ساده ومارپیچ باتماس غیرموضعی و برای $\nu=0.30$، C_P واحد $(\text{MPa})^{1/2}$ است

پینیون	مدول کشسان E، GPa	چرخدنده: فولاد	چدن چکش‌خوار	چدن داکتیل	چدن خاکستری	برنز آلومینیم	برنز قلع
فولاد	۲۰۰	۱۹۱	۱۸۱	۱۷۹	۱۷۴	۱۶۲	۱۵۸
چدن‌چکش‌خوار	۱۷۰	۱۸۱	۱۷۴	۱۷۲	۱۶۸	۱۵۸	۱۵۴
چدن داکتیل	۱۷۰	۱۷۹	۱۷۲	۱۷۰	۱۶۶	۱۵۶	۱۵۲
چدن‌خاکستری	۱۵۰	۱۷۴	۱۶۸	۱۶۶	۱۶۳	۱۵۴	۱۴۹
برنز آلومینیم	۱۲۰	۱۶۲	۱۵۸	۱۵۶	۱۵۴	۱۴۵	۱۴۱
برنز قلع	۱۱۰	۱۵۸	۱۵۴	۱۵۲	۱۴۹	۱۴۱	۱۳۷

نهایی و تسلیم آن به $S_u = ۸۰۰\ \mathrm{MPa}$ و $S_y = ۵۸۰\ \mathrm{MPa}$ برسد ساخته شوند. دندانه‌ها با تیغهٔ دندهٔ شانه‌ای تولید می‌شوند. اندازهٔ چرخدنده‌های موردنیاز را تخمین بزنید، از این حقیقت که لنگر راه‌اندازی موتور ممکن است بیشتر از لنگر بارکامل باشد چشم‌پوشی کنید.

حل. از جدول ۱۳-۱ در می‌یابیم که کمترین تعداد دندانه برای اجتناب از ریشه تراشی ۱۸ عدد است. بنابراین چرخدندهٔ ۷۲ دندانه‌ای را برای درگیری با پینیون ۱۸ دندانه‌ای انتخاب می‌کنیم؛ این عمل، کاهش ۴ به ۱ را می‌دهد.

هنگامی که چرخدنده و پینیون از یک ماده ساخته شوند، پینیون همواره ضعیفتر است چون دندانه‌های چرخدندهٔ کوچکتر، ریشه‌تراشی بیشتری دارد. (ببینید ضریبهای Y در جدول ۱۳-۳ چگونه تغییر می‌کنند.)

ازجدول ۱۳-۳، $Y = ۰٫۲۹۳۲۷$ را برای پینیون ۱۸ دندانه‌ای می‌یابیم. اگر ضریب ایمنی ۴ را انتخاب کنیم تنش خمشی مجاز $\sigma_p = ۱۴۵\ \mathrm{MPa}$ را به‌دست می‌آوریم. این داده‌ها به‌علاوهٔ داده‌های معلوم درمعادله‌های (الف) تا (ه)، به‌ازای $m = ۵$، ۶ و ۸ mm که به‌دلخواه انتخاب شده‌اند، وارد می‌شوند. نتیجه‌ها درجدول ۱۳-۶ نشان داده شده‌اند.

جدول ۱۳-۶ نشان می‌دهد که مدول $m = ۶\ \mathrm{mm}$، حلی به‌صورت $F = ۹۵٫۴\mathrm{mm}$ را نتیجه می‌دهد که در بالای گستره است. پهنای رویه‌ای به‌اندازهٔ ۹۵ mm، با توجه به ضریب ایمنی ۴، احتمالا انتخاب ارجحی است.

جدول ۱۳-۶ حلهای مثال ۱۳-۴

کمیتها	نتیجه‌ها		
مدول m، mm	۵	۶	۸
قطر d، m	۰٫۰۹۰	۰٫۱۰۸	۰٫۱۴۴
سرعت V، m/s	۵٫۲۸	۶٫۳۳	۸٫۴۴
بار W، kN	۱۴٫۲۱	۱۱٫۸۴	۸٫۸۸
پهنای رویه F، mm	۱۲۵	۹۵٫۴	۶۲٫۹
$F_{min} = ۳p$، mm	۴۶٫۲	۵۵٫۵	۷۴٫۰
$F_{max} = ۵p$، mm	۷۸٫۵	۹۲٫۲	۱۲۵٫۷

□

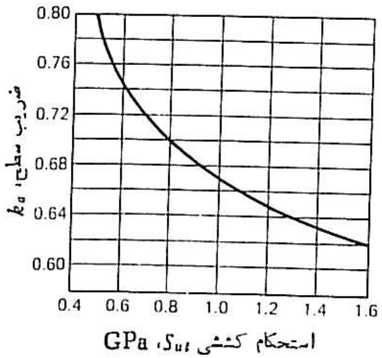
۱۳-۱۴ استحکام خستگی

حد دوام ماده‌های چرخدنده را می‌توان با استفاده از روشهای فصل ۷ به‌دست آورد. ساده‌سازیهای مشخصی برای چرخدنده‌ها مقدور است و بنابراین معادلهٔ (۷-۱۵) را برای راحتی دراینجا تکرار می‌کنیم.

$$S_e = k_a k_b k_c k_d k_e k_f S'_e \qquad (۱۳-۲۹)$$

که S_e = حد دوام دندانهٔ چرخدنده
S'_e = حد دوام نمونهٔ تیرچرخان
k_a = ضریب سطح
k_b = ضریب اندازه
k_c = ضریب قابلیت اعتماد
k_d = ضریب دما
k_e = ضریب اصلاحی تمرکز تنش
k_f = ضریب اثرهای گوناگون

پرداخت سطح. ضریب سطح k_a می‌بایست همواره مربوط به‌پرداخت ماشینکاری باشد، حتی هنگامی که ریشهٔ دندانه سنگ‌زده شده یا تراشکاری می‌شود. دلیل این است که سطح پایینی معمولا سنگ‌زده نمی‌شود، و به‌صورت پرداخت ماشینکاری شدهٔ اولیه باقی می‌ماند. برای راحتی، نموداری از ضریبهای سطح ازشکل ۷-۸ به‌صورت شکل ۱۳-۲۵ دراینجا آورده شده‌است.



شکل ۱۳-۲۵ ضریبهای پرداخت سطح k_a برای دندانه‌های چرخدندهٔ تراشیده شده، و سنگ‌زده شده.